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JOHN M. CLARKE Director

Bulletin 92

PALEONTOLOGY 13

GUIDE TO THE GEOLOGY AND PALEONTOLOGY OF THE SCHOHARIE VALLEY IN EASTERN NEW YORK

BY

AMADEUS W. GRABAU

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New York State Education Department

Science Division, Mar. 16, 1905

Hon. Andrew S. Draper

Commissioner of Education

DEAR SIR: I transmit herewith for publication as a bulletin of the State Museum the manuscript of a Guide to the Geology and Paleontology of the Schoharie Valley with a geologic map.

Very respectfully

JOHN M. CLARKE

Director

Approved for publication Mar. 16, 1905

A. S. Draper

Commissioner of Education

PREFACE

In the valley of the Schoharie creek the earliest systematic study of the paleozoic rocks of this State and the first successful attempt to classify the strata according to their fossils were made. While Amos Eaton was endeavoring to work out the order of the strata, chiefly from their rock characters in the region adjoining the Erie canal, the John Gebhards, father and son, were collecting fossils in the Schoharie valley and dividing the rock masses according to differences and similarities in these organic remains.

When the geological survey was organized in 1836, Lieutenant Mather, charged with the work in the first geological district which included Schoharie, sought the assistance of John Gebhard jr, who thus had the opportunity to verify and complete his classification.

The region is classic to the student of geology. In the brave days when Professor Eaton lectured on geology to the Legislature of New York and Governor Dewitt Clinton collected fossils in the leisure of his executive duties, the rocks of Schoharie were a source of stimulus and inspiration which have produced fine results in the history of this science.

Yet in all its history there has not been a geologic map of the region prepared except on an insignificant scale and no adequate account of its formations and structure have heretofore been given. It is to meet this condition, to provide students of geology and paleontology with a suitable map and guide to this attractive region that I have asked Professor Grabau to prepare the work that follows.

The Schoharie valley presents a geologic section almost unequaled in this State for its completeness. It begins low in the series with the last stages of the Lower Siluric (Lorraine) and runs high into the base of the Upper Devonic; its localities are compactly assembled and easily accessible. The valley is beautiful, fertile, hospitable and well supplied with the conveniences of living. The spot is ideal for the pursuit of an intimate acquaintance with a very considerable and typical representation of New York geology.

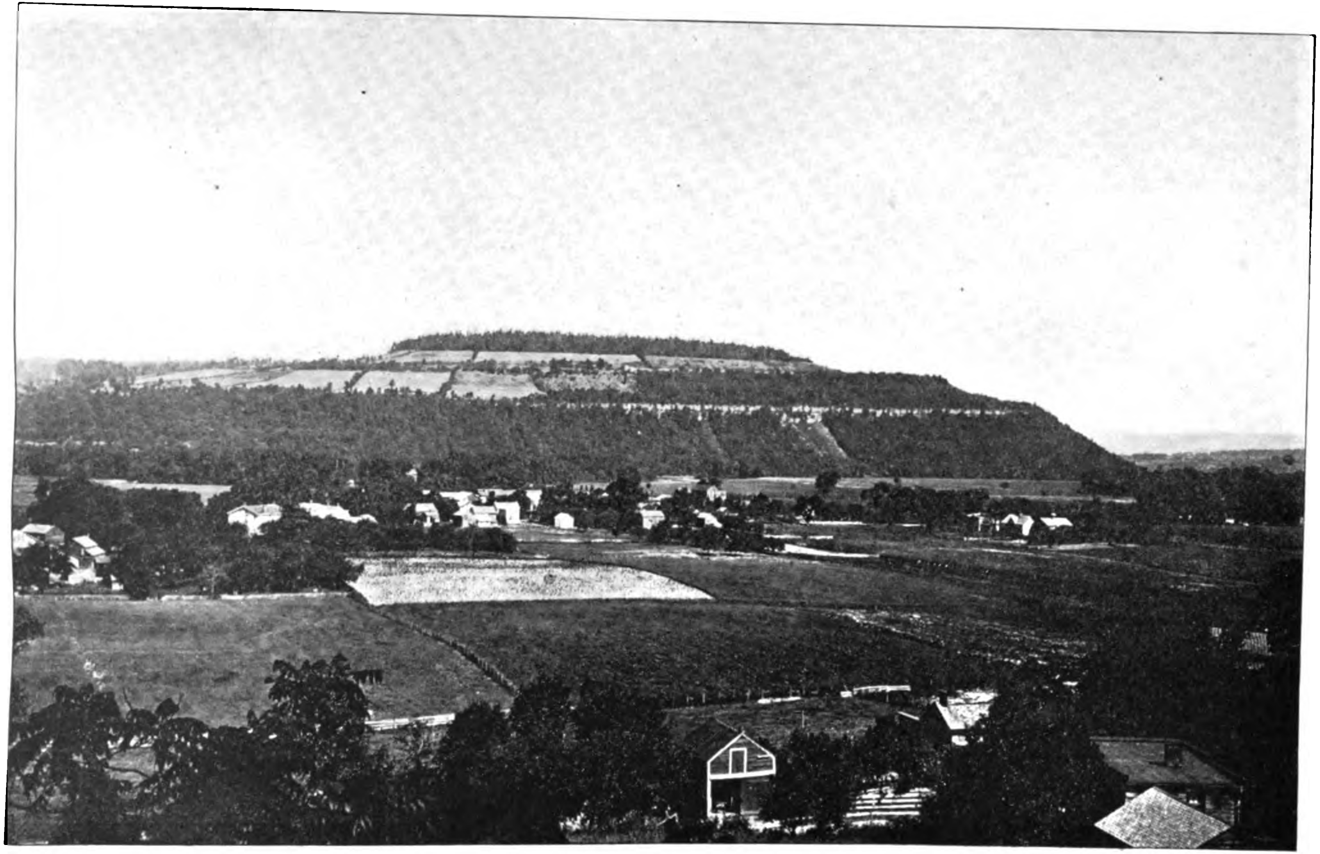
It is believed that this work will aid and stimulate students, clarify the geologic problems which the region presents and, as it is the outcome of a careful resurvey of the region, advance our knowledge.

JOHN M. CLARKE

State Geologist

January 1905

Plate 1



West hill or Terrace mountain from Lasell park. Schoharie valley in the foreground

New York State Museum

JOHN M. CLARKE Director

Bulletin 92

PALEONTOLOGY 13

GUIDE TO THE GEOLOGY AND PALEONTOLOGY OF THE SCHOHARIE VALLEY IN EASTERN NEW YORK

BY

A. W. GRABAU

INTRODUCTION

The village of Schoharie has long been famous for the fine stratigraphic sections which are exposed in its vicinity. The labors of Gebhard, Mather, Hall, Stevenson, Prosser, Darton and others have outlined the general succession of the strata and their relation to those of other portions of the State. Recently a careful study of the Coralline or Cobleskill limestone of the Schoharie region has been made by Mr C. A. Hartnagel, the results of which are given under the description of that formation in a succeeding chapter.

From the accessibility of the Schoharie valley and from the ease with which most of the formations can be studied in that vicinity, the region has always attracted students and teachers of geology and paleontology, and has indeed become one of the districts, a visit to which forms part of a geologic education. For this reason it has been felt that a comprehensive description of the geology of this region with special reference to the needs of the student was desirable. In order that this description might be of more general usefulness, even to those who have not been trained in geologic work, it has been deemed advisable to discuss principles freely, specially where these principles are well illustrated by local features. It may be said that some of the principles which have a vital bearing on the geologic history of the Schoharie region have not yet found their way into our current

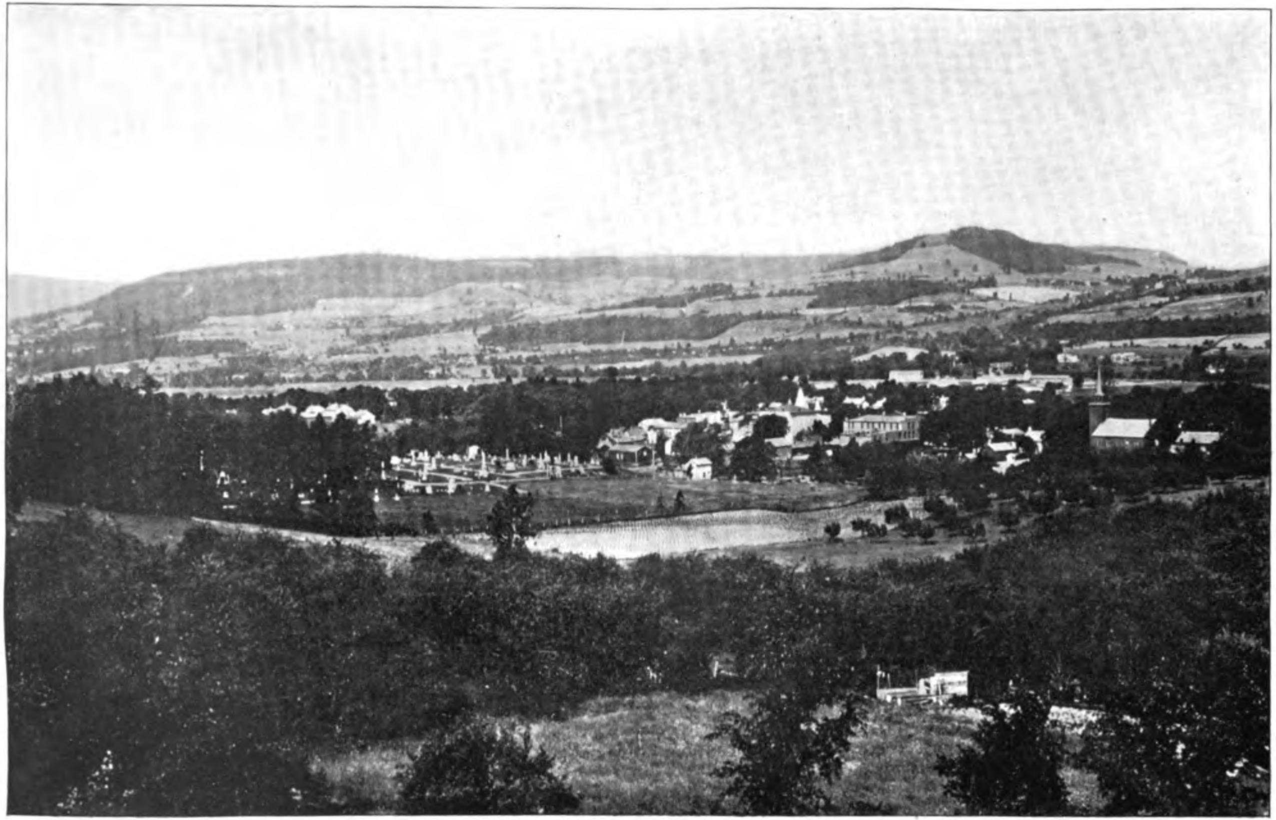
textbooks, though they form the basis of much of the geologic work of the day. For this reason it is believed that a somewhat extensive discussion of them will be welcomed not only by the lay reader, but also by the student of geology.

Various lists of the fossils characterizing the successive Helderbergian divisions have been published, notably for Countryman hill near New Salem, for Becraft mountain, for the region about Rondout and for the Port Jervis region. It has not been deemed necessary to describe all the fossils found in the Helderberg or higher strata of the Schoharie region, because in the descriptions of these fossils in the volumes of the *Palaeontology of New York*, account is taken of the species from Schoharie. A brief mention together with notation of the essential characters of the more important species of each formation, was considered sufficient, specially as the illustrations accompanying this notice will in most cases suffice for purposes of identification. In chapter 7, lists are given of the species recorded from the Schoharie district.

The detailed sections of Chapters 5 and 6, together with the discussion of the uppermost Siluric fauna, are addressed to the student of the Paleozoic formations, but the other chapters are primarily intended as a popular exposition of the geology of the Schoharie district.

Schoharie is reached from Albany, Schenectady or Binghamton by the Delaware and Hudson Railroad, which connects with the Schoharie Valley Railroad at Schoharie Junction. The town is situated on the east bank of the Schoharie river, on its flood plain, though low terraces of morainal material are found within its limits. On one of these morainal terraces is situated the old Lower Fort of the Schoharie valley, which played a not unimportant role in the early wars of the colony. Behind the town on the slopes of East hill is a terrace formed by the Coeymans limestone, with the Manlius beds at the base. Lasell park, reached most easily by a path through the cemetery behind the courthouse, forms a portion of this terrace, and from it one has a comprehensive view of the valley and the hills fringing it on

Plate 2



Sunset hill from Lasell park. Schoharie in the foreground

the west. Directly opposite is West hill, or Terrace mountain, so called from the fine terracing due to alternate hard and soft strata. The red barn of Mr George Acker forms a prominent landmark on the second terrace near the center of the hill. This is one of the best stratigraphic points of the region, and therefore deserves to be located at the outset [*see* pl.1]. Next south of West hill is Dann's hill, also terraced, but to a less pronounced degree than West hill. The terraces of the latter may be traced on Dann's hill, where they gradually descend southward, till a short distance beyond Gebhard bridge which crosses the Schoharie near the southern end of Dann's hill, the first of the terraces has reached valley bottom and passes below it. The summit of Dann's hill is composed of the soft Marcellus shales and hence is rounded, while that of West hill is flat, being formed by a resistant limestone (Onondaga).

Next south of Dann's hill is a long and rather rugged ridge terminating on the north in a prominent knob. This is Sunset hill and its summit is composed of the harder sandy shales of the lower Hamilton [pl. 2]. Beyond this is South hill, still more rugged and best seen from the streets of Schoharie, where it closes in the view on the south. This hill is almost entirely composed of the arenaceous Hamilton shales and flags and its steep slopes and occasional cliffs are due to the resistant character of the rock from which it is worn. The southern end of this hill terminates in Vrooman's Nose, a particularly distinct knob which faces southward with a precipitous cliff of Hamilton sandstones.

A view up the Schoharie valley from near Gebhard bridge on Fair street shows another and higher hill beyond Middleburg. This hill, known as Moheganter hill, closes in the Schoharie valley on the south, where this valley turns abruptly to the west, and its summit, 1500 feet above the valley bottom, forms a magnificent viewpoint. It may be ascended by a road which branches off from the valley road east of the river, about three miles southwest of Middleburg, at the schoolhouse of District no. 11. The upper part of the hill is formed by the Oneonta

formation, outcrops of which, and of the Sherburne and Hamilton formations, are common on this hill.

The physical geography of the Schoharie valley has been well described by Prof. Arnold Guyot (1880) in the following words:

The main Schoharie creek originates at the foot of the Schoharie peaks, near the head of the Plaaterkill clove, from which it is hardly separated by a slight swell in the swampy valley bottom. It follows closely the foot of the central chain and receives just below Tannersville its first affluent, also coming from swampy meadows near Haines's falls, at the head of the Kaaterskill clove; these two head streams embracing the chain of the High Peak. The creek, keeping the direction of the central chain to the west-northwest, flows through Hunter village, 1609 feet, to Lexington, 1320 feet, where it turns with the chain to the northwest, to the mouth of the Beaverkill creek, beyond Prattsville, 1164 feet.

Here it leaves the central chain, and, running almost due north to the confluent of the Manorkill, it enters the mass of the northwestern plateaus, cutting from Gilboa 1033 feet, to Middleburg 640 feet, a deep and narrow valley, the bottom of which is from 1000 to 1300 feet below the general level of the country it traverses, while the occasional flat bottoms in it at Blenheim, Breakabeen, Fultonham and Middleburg, rarely attain more than half a mile in width. Its course from Blenheim through Middleburg, Schoharie and Central Bridge, where it received the Cobleskill creek, is alternately to north-northeast and north. From this place, instead of following the broad valley through which runs the Albany and Susquehanna Railroad [Delaware & Hudson R. R.], it leaves it and cutting its way at right angles through the high hills which border the Mohawk it finally enters that river near Fort Hunter, after a course of over 76 miles.

All the main tributaries of the Schoharie creek in the mountain region, the Eastkill, the Bataviakill, the Manorkill, come from the northeast border chain and flow almost due west to the central chain, on the opposite side, where they enter the main creek; the Eastkill, three miles above Lexington, the Bataviakill just above Prattsville, the Manorkill at Gilboa. Like most valleys of erosion they offer, in their upper and middle course, a succession of flat and open basins from which they fall through narrows, in rapids and cascades, into the valley of the main creek. The left affluents from the central chain, the Westkill, Little Westkill, and the Beaverkill, are all inconsiderable in length and volume. In the region of the plateaus another West-

kill, on the west at Blenheim, and the Keyserskill on the east, at Breakabeen, are hardly more than mere torrents.

The contrast of the broad open valleys between the mountain chains above described and the narrow and deep cut of the Schoharie creek when passing through the plateau region is a feature to be noted.

This drainage which sends the waters of the Catskills all the way around to the Mohawk to come back by the Hudson after a course of 175 miles, to within 10 miles of their starting point, is certainly remarkable, and betokens a very peculiar physical structure. This is made more striking by the fact that on both sides of these highlands the waters of the valleys of the Catskill and Esopus creeks flow, as we might have expected, from the western plateaus directly to the Hudson river. These three streams which are so near each other, flow in opposite directions, and it seems as if this plateau of the Catskills had been lifted up on its eastern part to a higher level from which its waters were sent in the opposite direction.[1]

The present discussion of the geology of the Schoharie region is taken up in the order of the development of the region. The earlier chapters deal with the stratigraphy, the character, mode of deposition and fossil contents of each of the strata found in the district. For purposes of comparison brief references to other localities in the Helderbergs are frequently made. Chapters 5, 6 and 7 summarize the geology and paleontology of the region, the first two giving all the important local sections and the last lists of the fossils. The development of the surface features since Paleozoic time next claim attention and finally the relation of the region to man is discussed.

In the prosecution of this study I have been greatly aided by many friends. The state geologist and paleontologist, Prof. John M. Clarke, generously gave me a free hand in the development of the subject and provided means for the ample illustrations. Acknowledgments are also due to many Schoharie friends for numerous courtesies, specially to Prof. Solomon Sias, Mr E. H. Heck, Mr Claude Mayham and Dr Charles Lintner.

The following summary of papers dealing with the Schoharie region aims to take account of those only in which the geology of the region has received extended attention.

[1]Am. Jour. Sci., ser. 3. 19:442-43.

1834 Emmons, Ebenezer, reported the discovery of strontianite in the vicinity of Ball's cave, Schoharie. (Am. Jour. Sci. 1835. 27:182, 183)

1835 Gebhard, John, contributed an account of the geology and mineralogy of Schoharie N. Y. (Am. Jour. Sci. 38:172–177)

1837 A newspaper article on Crinoidea, or lily-shaped animals from Schoharie, was republished in Am. Jour. Sci. 31:165–167.

1843 Mather, William W., in Geology of New York, pt 1, "Geology of the First Geological District", published an account of the geology of the Schoharie region.

1853 "An Account of Knopfel's Schoharie Cave [Ball's Cave] . . . with the history of its discovery, subterranean lake, minerals and natural curiosities" appeared as a separate publication, apparently a reprint from a newspaper account.

1859 Hall, James, in Palaeontology of New York, v. 3, published "descriptions and figures of the organic remains of the Lower Helderberg group and the Oriskany sandstone", including those of the Schoharie region.

1867 Hall, James, in Palaeontology of New York, v. 4, published "descriptions and figures of the fossil brachiopoda of the Upper Helderberg, Hamilton, Portage and Chemung groups", covering the Schoharie region.

1877 Sherwood, Andrew, published a "Section of the Devonian Rocks made in the Katskill Mountain at Palenville; Kauterskill creek, New York". (Am. Phil. Soc. Proc. 17:346, 347)

1877 Sherwood, Andrew & Clark, published a "Section along Schoharie Creek in Schoharie county, N. Y., between Gilboa and Middleburg, from the Catskill down to the Upper Helderberg". (Ibid. p. 347–349)

1879 Hall, James, in Palaeontology of New York, v. 5, pt 2, published "descriptions of the Gasteropoda, Pteropoda and

Cephalopoda of the Upper Helderberg, Hamilton, Portage and Chemung groups", covering those of the Schoharie region.

1880 Guyot, Arnold, published a paper on the Physical Structure and Hypsometry of the Catskill Mountain Region, in which he discussed the physiography of the Schoharie valley [quoted above]. (Am. Jour. Sci., ser. 3. 19:442–443)

1884 Hall, James, published Palaeontology of New York, v.5, pt 1, Lamellibranchiata I (Monomyaria) of the Upper Helderberg, Hamilton and Chemung groups, including those of the Schoharie region.

1885 Hall, James, published Palaeontology of New York, v.5, pt 1, Lamellibranchiata II (Dimyaria) of the Upper Helderberg, Hamilton, Portage and Chemung groups, covering those of the Schoharie region.

1887 Hall, James and Simpson, George B. published Palaeontology of New York, v. 6, Corals and Bryozoa of the Lower Helderberg, Upper Helderberg and Hamilton, including those of the Schoharie region.

1888 Hall, James & Clarke, John M. published Palaeontology of New York, v. 7, Trilobites and other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill groups, containing those of the Schoharie region.

1893 Darton, N. H. published a report on the Relations of the Helderberg Limestones and Associated Formations in Eastern New York (N. Y. State Geol. 13th An. Rep't, v. 1) which deals largely with the Schoharie region.

1897 Prosser, Charles S. published Classification and Distribution of the Hamilton and Chemung series of Central and Eastern New York, pt 2 (N. Y. State Geol. 17th An. Rep't). This is replete with sections of the higher strata in the Schoharie region, some of which are reproduced in chapter 5.

1897 Prosser, Charles S. & Rowe, Richard B. published Sections of the Stratigraphic Geology of the Eastern Helderbergs (N. Y. State Geol. 17th An. Rep't) giving sections and lists of fossils at Clarksville, Onisketbau creek, New Salem and Countryman hill. Some of these are republished in chapter 6.

1898 Prosser, Charles S. published Sections of the Formation along the northern end of the Helderberg Plateau (N. Y. State Geol. 18th An. Rep't). In this detailed sections of the Helderberg and other strata of the Schoharie region are given; also characteristic sections of Altamont, Indian Ladder, Knoxville and other typical regions in the Helderbergs. Most of these are republished in chapter 6.

1900 Stevenson, J. J. published a Section at Schoharie (Geol. Soc. Am. Bul. 2:67), comparing it with sections in southern Pennsylvania and Virginia.

1901 Clarke, John M. discussed the Goniatite limestone and associated Marcellus shales in Schoharie county, and gives list of fossils and localities of the Goniatite stratum (N. Y. State Mus. Bul. 49. 1901. p. 123–25).

1901 Clarke, John M. mentions the occurrence of Amnigenia catskillensis in the red sandstones (Catskill) on the road from Jefferson to Gilboa and at the base of the hills south of Jefferson, Schoharie co. N. Y. He further discusses the "Value of Amnigenia as an Indicator of Fresh-water Deposits during the Devonic of New York, Ireland and the Rhineland. (Ibid. p. 199–203)

1901 Ries, Heinrich in an "Account of the Lime and Cement Industries of New York" discussed the section at Howes Cave and the production of cement [N. Y. State Mus. Bul. 44].

1901 Eckel, Edwin C. in "Chapters on the Cement Industry in New York" gives an account of the cement industry of the Helderberg Cement Co. at Howes Cave [Ibid. p. 869–70].

1903 Schuchert, Charles published a paper on the Manlius formation of New York [Am. Geol. March 1903] in which he gives the principal sections and suggests that the Cobleskill belongs in the basal portion of the Manlius formation.

1903 Prosser, Charles S. published "Notes on the Geology of Eastern New York" [Am. Geol. 32:380] in which he corrects his former sections, chiefly in the nomenclature.

1903 Hartnagel, C. A. in "Preliminary Observations on the Cobleskill ("Coralline") Limestone of New York" gives detailed sections with lists of fossils of the Cobleskill of the Schoharie and other regions [State Paleontol. 1902, An. Rep't; N. Y. State Mus. Bul. 69, p. 1109–75], and shows that it is of Postsalina age. He considers it a distinct formation which is not to be included as a part of the Manlius.

1904 Sias, Solomon in "A Summary of Schoharie County" gives the "Organization, Geography, Geology and History" of Schoharie. The formations are briefly discussed and localities where each may be found are given. The glacial geology of the region is also briefly discussed.

1904 Harris, G. D., in an article on "The Helderberg invasion of the Manlius," published sections of the Schoharie and Helderberg regions and compared them with other New York sections [Am. Bul. Pal. 4, p. 51].

Chapter 1

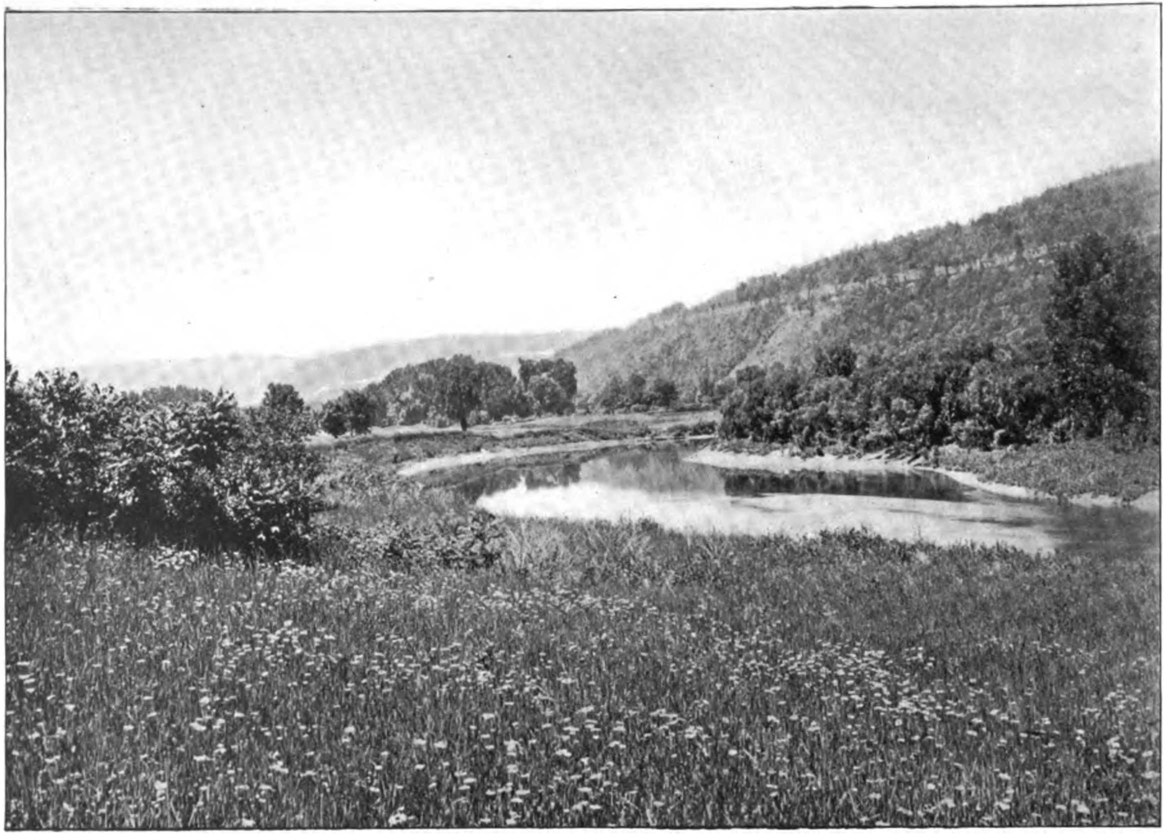
STRATIGRAPHY OF THE SCHOHARIE REGION

General characteristics and extent of formations

In the Schoharie region there are 20 well defined geologic formations or terranes, 13 of which are differentiated in the accompanying map. They comprise sandstones, shales and limestones which succeed each other in a definite and ascertained order, and the character, thickness and fossil content of individual beds scarcely vary over the entire area under discussion. A glance at the map shows that the outcrops of these strata are deflected in loops up the valley of each of the three principal streams of the region, the Cobleskill, the Schoharie kill and the Fox kill.[1] Around the Schoharie valley, the loops of all the strata appear complete on the map, around the Cobleskill valley they are only partially complete, while none of the loops cross the valley of Fox creek so far as shown on the map. The loops of the Cobleskill and the Fox kill valleys would appear complete if the map extended further west and east. The looping of the outcrops is principally due to the fact that the strata all incline or dip towards the southwest. Thus as we follow up the Schoharie valley or the Cobleskill valley, higher and higher beds approach successively the plane of the valley and pass beneath it, the cut edges of each bed on opposite sides of the valley thus joining, where the bed and the valley floor intersect. In the Schoharie valley, the slight southward rise of the valley floor—from 611 feet at Schoharie (Gebhard bridge) to 634 feet at Middleburg, or only 23 feet in four miles, i. e. 6 ft to the mile, scarcely influences this looping of the strata edges which is here almost wholly due to the dip of the strata. On the other hand, the more rapid rise of the narrower valley floor of the Cobleskill,

[1] The termination "kill" is the Dutch for stream or creek. This meaning is often lost sight of and the word creek added. Thus we have Cobleskill creek, Catskill creek, etc. while on the other hand the word kill, formerly used, has often been replaced by creek, as Schoharie kill by Schoharie creek, Fox kill by Fox creek, etc.

Plate 3



View of West hill and the Schoharie valley and creek; looking south. South and Moheganter hills in the background, the latter on the extreme left. The prominent cliff in West hill is formed by the lower Coeymans limestone

from 600 feet at Central Bridge to 720 at Howes Cave bridge, 820 at Barnerville bridge and 900 feet at Cobleskill, or 300 feet in 8 miles, i. e. 37½ feet to the mile, counteracts the diminished dip of the strata. Thus the loops around the Cobleskill valley are not much longer than those surrounding the Schoharie valley, even though the dip along the axis of the former valley is only about 50 feet to the mile or approximately 1 foot in 100, whereas in the Schoharie valley it approximates 135 feet to the mile or about 1 foot in 40. In the case of the Schoharie valley then we have a nearly level river plane intersecting a strongly dipping stratum plane; in the Cobleskill valley, a moderately dipping stratum plane is intersected by a rising river plane. The results in either case are nearly the same.

The valley of the Fox kill differs from the other two, in being cut nearly parallel to the strike of the strata or even somewhat down the dip. This accounts for the difference in the character of the outcrops which are nearly parallel on opposite sides of the valley. The looping of the outcrops of the lower strata around the Fox kill valley, which occurs some distance east of the limit of the map, is here due entirely to the rise of the valley floor, which successively intersects the horizontal planes of the strata. Thus we have three relations of strata and river valley, all of which produce the effects of deflected outcrops, namely 1) declining strata and horizontal valley floor as in the Schoharie, 2) declining strata and rising valley floor as in the Cobleskill, and 3) horizontal strata and rising valley floor as in the Fox kill.

Most of the smaller streams of the region have also caused an upstream deflection of the contact lines between formations. This is due to the fact that these streams generally have their origin in the hills on either side of the greater valleys and have cut ravines of greater or less magnitude. In these ravines the contact lines are deflected but where the streams run across the contact lines in the valley bottom, no such deflection takes place. Not infrequently the contact line which has the most pronounced deflection is that which separates a harder from an overlying softer bed. The softer bed has been eaten away by the stream,

while the harder bed is scarcely affected. This is well illustrated by the contact line between the Onondaga and lower Hamilton (Marcellus) formations wherever it is crossed by streams, the Onondaga being a very resistant limestone formation while the shales above it are easily removed.

Age and structural relations of the strata. All the rock formations outcropping in the Schoharie region were deposited during three of the eras of Paleozoic time namely; the Champlainic, the Siluric or Ontaric and the Devonic. Only a portion of the Champlainic and Ontaric eras is represented by the formations of this region, while the lowest or Cambric (Taconic), and the highest or Carbonic of the Paleozoic eras are not represented. The former lies far below the surface, and could only be reached by boring, while the latter, if it ever existed in this region, has long since been worn away entirely. From what has been said regarding the southwestward dip of the strata, it will be seen that the lower beds, hidden in the Schoharie region, will appear from beneath their covering of higher beds as we pass northward. If, for example, we follow the Schoharie creek northward to its junction with the Mohawk at Fort Hunter, we find successively lower and lower strata appearing in its bed and banks, till on the Mohawk we have reached the Trenton limestone which at Schoharie is approximately 3500 feet below the bottom of the valley. If we proceed still farther north, we find that twenty miles north of the mouth of the Schoharie kill the crystalline rocks of Precambric age appear, which form the Adirondack mountains, and lie approximately 4000 feet below the valley bottom at Schoharie. If, on the other hand, we go southwestward we meet with successively higher and higher strata, even though we do not rise much above the level of the Schoharie hills. It is not till we near the Pennsylvania line, however, that we meet with rocks belonging to the Carbonic era, and not till we have passed the state line, do we reach the coal-bearing strata. The significance of this fact will be dwelt on more fully in the discussion of the search for coal in this region. The relationship is shown in the following diagram [fig. 1].

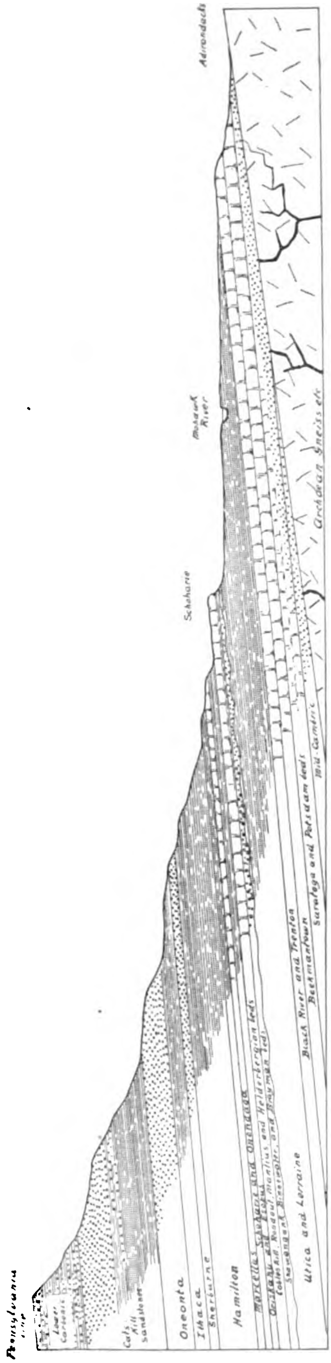


Fig. 1 Diagrammatic section from the Adirondacks to the Pennsylvania line

The following table shows the succession of formations in this region, of which those above the Hamilton of the Devonic and those below the Lorraine of the Champlainic are not shown in the area covered by the map.

Carbonic absent from this region.

		GROUP	STAGE
Devonic	Upper	Chautauquan	Catskill
		Senecan	Oneonta Ithaca Sherburne
	Middle	Erian	Hamilton Marcellus
		Ulsterian	Onondaga Schoharie
	Lower	Oriskanian	Esopus Oriskany
		Heldbergian	Port Ewen Becraft New Scotland Coeymans
Siluric or Ontaric	Upper	Cayugan	Manlius Rondout Cobleskill Brayman Basal (Binnewater ?) sandstone
Hiatus and stratigraphic unconformity			
Champlainic	Upper	Cincinnatian	Lorraine Utica
	Middle	Mohawkian	Trenton Black River Lowville
	Lower	Canadian	Chazy Beekmantown
Cambric or Taconic	Upper	Saratogan	Potsdam
Hiatus and structural unconformity			

Crystalline Archean and Algonkian

At two levels in the table a hiatus occurs which in each case marks an important physical break in the series, and a time

interval unrepresented in this region by strata. The lower of these breaks is a true unconformity as recognized in regions of disturbed strata; the upper may also be spoken of as an unconformity, but in a limited sense. In cases to which the term is most generally applied we have a discordance of dips between the two series, indicating a period of folding and subsequent erosion which precedes the deposition of the higher strata. The following diagrams indicate this kind of unconformity, to which

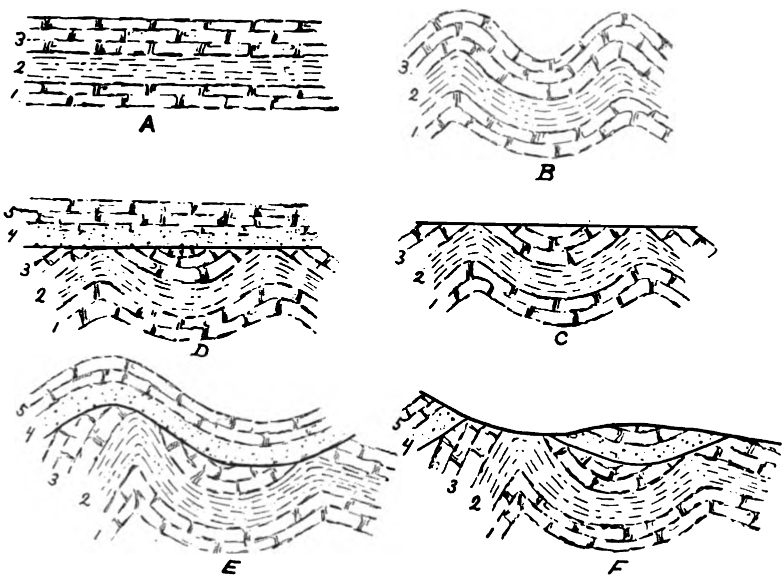


Fig. 2 A-F Development of a structural unconformity

the term "structural unconformity" may be applied for purposes of definition. Figure 2 a–d represents the condition from the deposition of the first bed to the end of the deposition of the second bed, and figure 2 e, f the results of another folding and subsequent erosion.

Unconformities of this type are not shown in the Schoharie region, but they may be observed in the Rondout-Rosendale region, southeast from Schoharie. Figures 3 a, b illustrate the type of "stratigraphic or stratic unconformity" found in this region between the Champlainic and Siluric formations as shown in the table.

Here the strata are nearly or quite concordant though there may occur a discordant line of contact between the two as shown in figure 3 b. This latter type of unconformity is not readily recognizable, and in fact would not be noticed except for the fact that a number of formations are missing between the strata in question. In the past very many such stratic unconformities have been overlooked, with the result that the geologic history of the region in which they occur has been misinterpreted.[1]

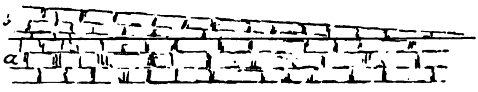


Fig. 3a Stratigraphic unconformity

The time intervals represented by the two unconformities indicated in the table are considerable. The one at the base of the series is by far the greatest, representing not only the Middle and Lower Cambric but probably also a considerable portion of late Algonkian time. The stratic break between the Champlainic and Siluric represents in this region the time interval during which the Lower and Middle Siluric strata were deposited in other localities. The details of this uncomformity will be discussed under the chapter dealing with the Champlainic and Siluric strata.

Another principle which is of great importance in the interpretation of the geologic history of this region, is that of *progressive overlap* of the strata and the attendant change in the character of the strata themselves. This principle, while generally recognized in a tacit manner, is too often overlooked where a direct application should be made. A brief discussion and illustration of the principle may therefore be given, specific illustrations from this region being deferred till the strata involved are discussed.

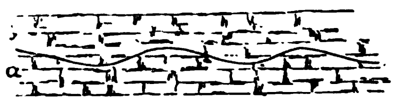


Fig. 3b Stratigraphic unconformity

It is a well known fact that along a normal seashore where there is a difference in the texture of the detritus, the coarsest

[1] The author has recently proposed the term discomformity for this type of break in the stratigraphic series [Science, n. s. 22:534].

material will be deposited near the shore and the finer at a greater distance from the shore in direct proportion to the fineness of the grain. Thus the impalpable powder or rock flour may be carried out to a great distance. In general we have close to the shore the rubble deposits, which may be angular or more or less waterworn to the condition of completely rounded and smooth pebbles. In size this rubble deposit may vary from small pebbles up to boulders many feet in diameter. From the consolidation of such material we obtain "rubble-rocks." At a somewhat greater distance from shore the sands are deposited, which may also vary in size from less than a pebble to that of a barely recognizable fragment, and may be either angular or rounded. Consolidation of this material produces sandstones. Finally the impalpable rock flour is deposited only in quiet water, and by its consolidation produces mudrocks. From what has been said regarding the loci of deposition of these various rocks it will be evident that the mudrocks alone are likely to show uniformity in bedding, thickness etc. The sandrocks and conglomerates, while as a whole remaining of uniform thickness will show considerable diversity in their individual beds, cross-bedding, ripple marks, and lenslike thinning and thickening of beds being common characteristics.

The chemical composition of these types of fragmental or clastic rocks is of course determined by that of the parent ledges from which the material is derived. It will be pure silica if all but the quartz is removed, which, if the texture is coarse, produces silicious conglomerates, a type of rock best represented by the quartz pebble conglomerates, though other quartz rubble rocks also occur. Pure quartz sandstones and pure quartz mudrocks are also produced when the texture is arenaceous and muddy respectively. Most of the silicious rocks of the Schoharie region are rendered more or less impure by the admixture of clay or iron, but a nearly pure quartz sandstone is found in the basal Siluric sandstone. When the parent rock is limestone or an organic deposit of corals or shells, such as coral reefs growing at a distance from the shore, the clastic rock of that locality may consist

wholly or in large part of lime. Thus we have lime rubble rocks represented in this region largely by limestones carrying worn fragments of corals, lime sandrocks, well represented by limestones composed of ground-up but not pulverized shells, crinoids, corals etc.; and lime mudrocks composed of the limestone flour, deposited in quiet water, and having a compact texture, where individual grains are not recognizable. This latter type of rock is well represented by the waterlimes and other close textured limestones of the Schoharie region. When the shore from which clay or silica is derived is near enough, impurities of these substances may become admixed with the lime, thus producing argillaceous or silicious lime mudrocks, etc.[1]

From the foregoing it becomes apparent that fragmental rocks of varying texture and composition will be deposited at the same time, in different parts of the ocean. Furthermore the same bed may change in texture and composition within a comparatively short distance. Thus a quartz conglomerate at the shore will grade into a quartz sandrock away from the shore, and if coral reefs or shell heaps are growing off the shore, it will gradually grade into a calcareous quartz sandrock (calciferous sandrock) then a silicious lime mudrock (silicious limerock) and finally a more or less pure lime sandrock or lime mudrock. In section such a bed would be thin at the shore where the water is shallow, rapidly thickening seaward till the maximum is reached, and then thinning away gradually in the deeper water as the material becomes finer, and accumulation therefore slower.

Three lines of activity may be considered in a normal seashore where deposits of this type are forming. First, the sea level may

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[1] The author has recently proposed the terms rudaceous, arenaceous and lutaceous for rubbly, sandy and muddy textures respectively. For clastic rocks of this texture, irrespective of composition, the terms rudyte, arenyte and lutyte have been proposed. Where the composition is pure the chemical name may be added. Thus lime mudrocks are calcilutytes, lime sandrocks are calcarenytes and lime rubblerocks calcirudytes. See further Geol. Soc. Am. Bul. 14:337 and Am. Geol. 33:228.

be a stationary one.[1] In such a case, where the supply of material is constant, the conglomeratic and arenaceous material near the shore will soon fill the water and thus the shore will migrate seaward. Conglomerates and sandrocks will therefore gradually creep out over the previously deposited offshore rocks (clays and calcareous rocks), these beds thus becoming overlaid by a shore deposit. This explains the upward changes in the character of successive beds from clay rocks to sandstones or conglomerates, the transition being a more or less gradual one.

In the second case the sea level may be a falling one. Under such conditions the shore would migrate seaward, but at a more rapid rate than occurs in the case of a stationary sea level. The result would be that previously deposited beds would be subjected to reassortment by the waves, the finer material being carried further out, while the coarse material will follow the shore outward over the previously deposited finer material, if that is not all worn away. The general effect will be similar to that of the first case, except that the deposits would decrease in thickness instead of remaining nearly the same. This, as in the preceding case, would result in the change from a finer to a coarser rock, with this difference, that the change would be an abrupt one, and more or less worn pebblelike fragments of the underlying finer rock would be included in the coarse rock. Examples where "mud pebbles", i. e. fragments of only partially lithified mud beds, are included in sandstones overlying the shales resulting from those mud beds, are not at all uncommon in the Schoharie region.

The third case and the one of most significance, is that of a rising sea level, or a subsiding shore. Wherever deposits of great thickness accumulate this state of relative condition must

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[1]The effect of a stationary sea level is produced where there is an increase in sediment brought in, even though continued subsidence goes on. Likewise the condition of a falling sea level is produced in an area of slow subsidence by a great increase in the detritus supplied. The results will be essentially the same as they would be in a stationary or a falling sea level, with a constant supply of material, except that we have an upward *gradation* from fine to coarse texture. [*see* A. W. G. Wilson, Can. Rec. Sci. July 1903. v. 9, no. 2.]

obtain, even though temporary rest periods may intervene. A rising sea level means a landward advancing shore and this implies that each later deposit reaches farther up on the shore than the preceding ones. In other words there is, under normal conditions of deposition, a constant and progressive overlapping of the later over the earlier layers. Any given formation will thin shoreward, but this is due to the fact that only the later beds of the formation are involved in the thinning wedge, the thinnest portion far up on the shore consisting only of the highest beds composing it. This is illustrated in the annexed diagram [fig. 4a].

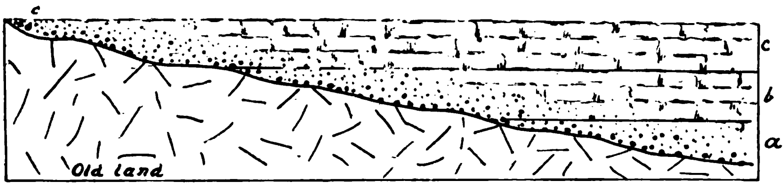


Fig. 4a Diagram illustrating progressive overlap

Again, in a normal series of deposits against a shelving shore each formation from the lowest up will in turn come to rest on the old land, the earlier formations having come to an end. Thus in the left-hand portion of the diagram [fig. 4a] formation *c* rests on the old land without the intervention of *a* or *b*. Conversely away from the shore, each formation becomes gradually underlaid by earlier beds which appear between it and the old land. It must also be borne in mind that apart from exceptional cases there is a progressive shoreward change in the lithic character of a bed and that in any given region this change may be uniform in successive beds. Thus a bed may consist of silicious pebbles at the shore, become a silicious sand farther out, and a calcareous sand or a clay at a distance from shore. Each succeeding formation will carry its pebble portion farther up on the shore, its sand facies thus coming to lie more or less directly above the pebble facies of the preceding bed. As the progressive advance of the seashore may be assumed to be a uniform one, the pebble facies of successive formations will have the appearance of a continuous

bed parallel to the floor of the old land and the sand facies will form apparently continuous beds parallel to the pebble beds, both thus constituting lithic beds, which extend diagonally across the horizontal planes that demark the time limit of the formations. This relation is shown in the subjoined diagram [fig. 4b. *See also* fig. 4a and fig. 5]. It is evident that neither the conglomerate nor

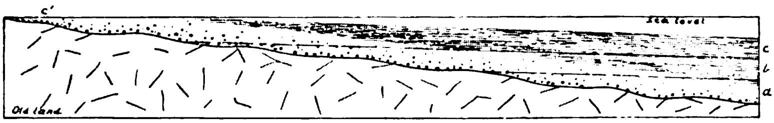


Fig. 4b Diagram illustrating progressive overlap

the sandstone thus produced will be of the same age throughout, the age of these beds becoming more recent in the direction of shore migration. The bearing of this fact on the age of some of the Siluric conglomerates and sandstones of the regions adjoining the Schoharie district, will be discussed in a later chapter. The relationships of the strata to each other and to the old land are shown in the subjoined figure [fig. 5].

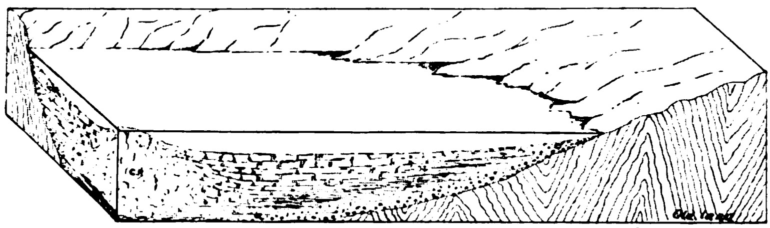


Fig. 5 Progressive overlapping of formations on old land. C. R. coral reef: source of the limestones

Bearing in mind the conditions just discussed, it becomes evident that through differential erosion, conditions which are very misleading may be brought about, as indicated in the following diagram [fig. 6] where a similar lithic succession is found on opposite sides of the old land axis, without correspondence in age.

This also explains why in one section a certain formation, constituting at that point the base of the sedimentary series, may be thin, while a short distance away it rapidly thickens without lithic

change. The thin portion does not represent the whole of the thicker portion but only the upper part. It likewise shows how within a short distance new members may appear below the one forming the base in the first section.

With the normal conditions thus outlined we are still confronted by another fact which seems to form a marked exception

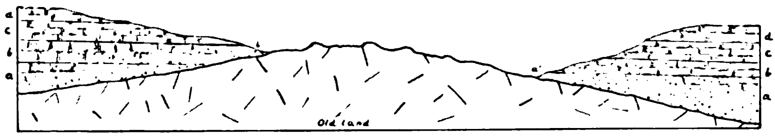


Fig. 6

to the general rule. We not infrequently find clastic limestones whose character, resting directly on an old land of silicious rocks on which they were deposited, indicates a shallow sea. Nevertheless silicious clastic material is almost or quite absent from these rocks. In such cases the only explanation seems to be that the water was shallow a considerable distance from shore and that the shore was worn down so low that little or no detritus could be supplied; i. e. worn down to a peneplain.

Plate 4

Brayman shale capped by Cobleskill limestone; on the river road near Howe's Cave

Chapter 2

STRATIGRAPHY OF THE SCHOHARIE REGION (continued)

The Champlainic and Ontaric (Siluric) formations and their relationships

Champlainic strata. The lowest beds exposed in the region covered by the accompanying map belong to the Lorraine formation of the Upper Champlainic division. The portion accessible within the area comprises fully six hundred feet of shales and sandstones. In the deep well at Altamont, some miles northeast of the eastern limit of the map, 2880 feet of sandstones and shales were found above the Trenton limestone. This added to about 600 feet exposed on the cliff behind Altamont gives a total of 3480 feet for the combined thickness of the Lorraine and Utica of this region.

Continuous exposures are comparatively rare in the Schoharie region, though fragments of the sandstones are common everywhere and on account of their flatness are extensively used in stone fences. Good exposures however are found in the gorges of the Bozenkill, Normanskill, and the lower Schoharie, but all of these are outside the limits of the map. The most accessible and continuous exposure of the upper portion of these strata is in the longer of the two small brooks which have incised themselves in the hillside on the west bank of the Cobleskill, and which join that stream halfway between Central Bridge and Howes Cave [map: VII i, 20]. In the banks of this stream above the road the horizontal shales are exposed. The lower beds are chiefly clay rocks, though some beds are quite arenaceous, with mica scales on the bedding planes. All the beds are traversed by two sets of joints, which cause the formation of rhomboidal blocks. Above these micaceous sandrocks are soft gray clay shales with an unctuous feel, and splitting into small fragments. Arenaceous matter seems to be wholly absent from the mass of these shales, with the exception of several one inch layers of sandstone, which appear at intervals. These shales are capped by rather coarse

silicious sandstones which appear abruptly, without transition. The first bed is 15 inches thick, then follow 4 to 6 inches of shale like that underlying the sandstone and then other beds of sandstone similar to the first succeed. The abrupt change from soft argillaceous shale to massive sandstones indicates a cessation of subsidence, or an elevation of the sea floor, and a creeping out of the shallower water conditions with their attendant sand deposits over the region where previously only muds were laid down. There are in all something over a hundred feet of these sandstones, though near the middle of the mass the beds have become shaly again.

No fossils have been found either in the shales or the sandstone. Extended search, however, will undoubtedly bring to light some of the characteristic Upper Champlainic species. Lower beds than those exposed in the creek are found on the Delaware and Hudson Railroad southwest of Central Bridge. Here again heavy-bedded sandstones occur between the shales.

The lower beds of the series are exposed along the Schoharie and its tributaries north of Central Bridge and may be traced as far north as the house of Mr William Bega, 3 miles south of Mill Point, or 7¼ miles south of Tribes Hill station, where they are seen to rest on the Utica shales in the bank of the creek. In the bank of the stream are exposed 114 feet of clear black shale which represent the Utica horizon. Above this follow 195 feet of grayish sandstones alternating with bluish argillaceous shales to the top of the cliff. These represent the lowest Lorraine beds, the contact with the Utica being a pronounced one.[1] What are probably the highest beds of this series are well shown in the roadway leading from Mix and O'Reilly's quarry at the stone crusher, in the northeastern part of the Schoharie village. The lowest beds exposed are dark arenaceous shales, succeeded by a purplish gray dark silicious sandstone a foot in thickness. Above this are about 20 feet of a lighter, yellowish or reddish, somewhat friable

[1] Prosser, C. S. Notes on the Stratigraphy of the Mohawk Valley etc. N. Y. State Mus. Bul. 34, p. 470.

silicious sandstone, sometimes with a slight admixture of argillaceous material. The texture is rather coarse, often somewhat pebbly with small flat pebbles of argillaceous sandstone. The lower portion of this series consists of thin beds, the upper of more massive layers. They are succeeded by 27 feet of the pyritiferous Brayman shales. There is some reason for regarding at least the upper 20 feet of sandstones as belonging with the Brayman shales rather than the Lorraine. Before considering this question, however, we must discuss the

Siluric strata of the Schoharie region

Only the Upper Siluric beds are found in the Schoharie region and there is every evidence that these are the only ones which were ever deposited here.

Brayman shales

Clinton shales; Salina shales; of authors

These with the exception of the basal sandstones, are the only beds of the Salina period occurring in this region. They have been variously described in the literature as Clinton shales, pyritiferous shales, Salina shales, etc. The name Brayman shales is chosen for them from the village of Braymanville on the Cobleskill, between which place and Howes Cave they are well exposed. As the shales have so far proved unfossiliferous their exact equivalency is somewhat uncertain. From their position immediately below the Cobleskill limestone it may be confidently inferred that they are of Salina age, but whether they represent the Bertie waterlime of Buffalo, which is the immediate predecessor of the Cobleskill of that region, or whether they are of somewhat earlier age is a question difficult to determine. That there is a slight hiatus between the Brayman shales and the Cobleskill seems to be indicated by the fact that the upper bed of these shales is somewhat conglomeratic, with rounded or elongate pebbles of clay shale inclosed in a dark matrix, partly a calcareous sand and containing numerous scattered rounded quartz grains. This indication of wave activity at the end of deposition of the

Brayman shales, and the want of transitional beds between the clay shale and the lime sandrock (Cobleskill) suggests that there is a short time interval unrepresented. This fact, together with the distinctive character and local development of these shales, demands their description under a separate name, as a local member of the Salina series of deposits, whose exact equivalent in the complete Salina series of Central New York is doubtful.

The main mass of the Brayman shale is an olive or grayish clay rock often alternating with bluish beds and weathering to a lighter color, and having the appearance of a solid mudbank. Concretions of iron pyrites are very abundant and of all sizes, though generally not much larger than a man's fist. The pyrite is commonly an aggregate of crystals, often of considerable size, the cube and pyritohedron being about equally represented. Exposed portions rapidly oxidize changing to an ochery color, and commonly stain the adjoining shales. As already noted, no fossils have yet been found in this formation.

The best exposure of these shales is in the ravine of the shorter of the two streams which join the Cobleskill between Central Bridge and Howes Cave. Here, at the foot of a fall formed by the Cobleskill limestone, about 20 feet of the shales are well exposed. The constant play of the water over these shales keeps the exposure fresh and the true color of the shales unaltered. The pyrite nodules too are mostly fresh, oxidation affecting the surface of some, while others remain perfectly bright.

The most complete exposure of these shales is along the west bank of the Cobleskill between Braymanville and Howes Cave. About half way between the two stations on the road which skirts the river bank, occurs a good exposure. A short distance north of Braymanville, a strong stream of water issues as a spring from a cavity at the base of the Cobleskill. This stream supplies a watering trough by the roadside and is strong at nearly all seasons of the year. This illustrates a very characteristic feature of these shales, namely their imperviousness, which cause springs to issue all along the line of outcrop of these strata. Below the cement kilns at Howes Cave is an exposure of over 30 feet of these shales

capped by the Cobleskill limestone. Hartnagel holds that the total thickness in this region is approximately 40 feet.[1]

One of the most accessible exposures of this formation is on the left bank of the Schoharie, a short distance above the Fair street bridge (Gebhard bridge) on the Gebhard farm. Here several excavations have been made in search of ore, and the upper part of the shales, together with the overlying Cobleskill, are well exposed. This locality has long been known for the pyrite crystals which can here be obtained, while the upper beds have yielded arsenopyrite.[2]

Near Mix and O'Reilly's quarry northeast of Schoharie, Hartnagel's measurement showed 27 feet of these shales. This gives a decrease of 13 feet in a distance of five miles. At this point, near the crusher, the contact with the underlying sandstone is well exposed, the two series of strata being absolutely conformable. The surface of the sandstone, exposed for several hundred yards, appears to be a perfectly normal deposition surface, and no trace of erosion, such as we might expect if there was an interval covering Lower and Middle Siluric time, is visible. Moreover the sandstone is pyritiferous like the shale, and no fragments of the lower rock are found in the Brayman shales. Neither does the surface of the top sandstone layer show traces of weathering before the deposition of the Brayman shales.

It is inconceivable that the surface of this sandstone, even if worn down to a uniform stratum, should be swept absolutely clean before the shales were deposited, so that no fragments of sandstone are found in the shale. It is clear that all the facts point to the intimate relationship between the upper beds of sandstone and the Brayman shales, making these sandstones of Upper Siluric (Salina) age. The unconformable contact between these sandstones and the Champlainic beds (Lorraine) must be looked for some distance down in the sandstone series.

The most easterly extension of the Brayman shales, so far as has been observed, is according to Hartnagel . . . "near

[1] *Loc. cit.* p. 114.
[2] This information was furnished me by Prin. Solomon Sias of Schoharie.

Gallupville, 5 miles east of Schoharie, showing that the extreme eastern extension of the great Salina beds of New York can not be far from the town of Knox, Albany co., at which place it is quite likely that the Cobleskill slightly overlaps the Salina. Both of these formations are absent at Altamont, a few miles farther east, and the Rondout is seen resting directly on the Lorraine beds."[1]

The age of the shales here considered has been variously judged. The name pyritous or pyritiferous shales was applied to this formation by the early geologists, and since it occurred below the Coralline or Cobleskill limestone, which was regarded as of Niagara age, and above the Shawangunk grit, which was supposed to be the equivalent of the Oneida conglomerate of central New York, its age was assumed to be Clinton. Recent investigations, by Ulrich and Schuchert, and by Hartnagel, have shown that the formation in question is of late Siluric age, the former authors regarding it as a part of the Cobleskill and including it within the Manlius series, while Hartnagel, Clarke and others regard it of Salina age. As will be shown presently, it is probably the partial equivalent of the lower cement bed of Rosendale which in turn represents a part, but probably not the whole, of the Bertie waterlime series of western New York.

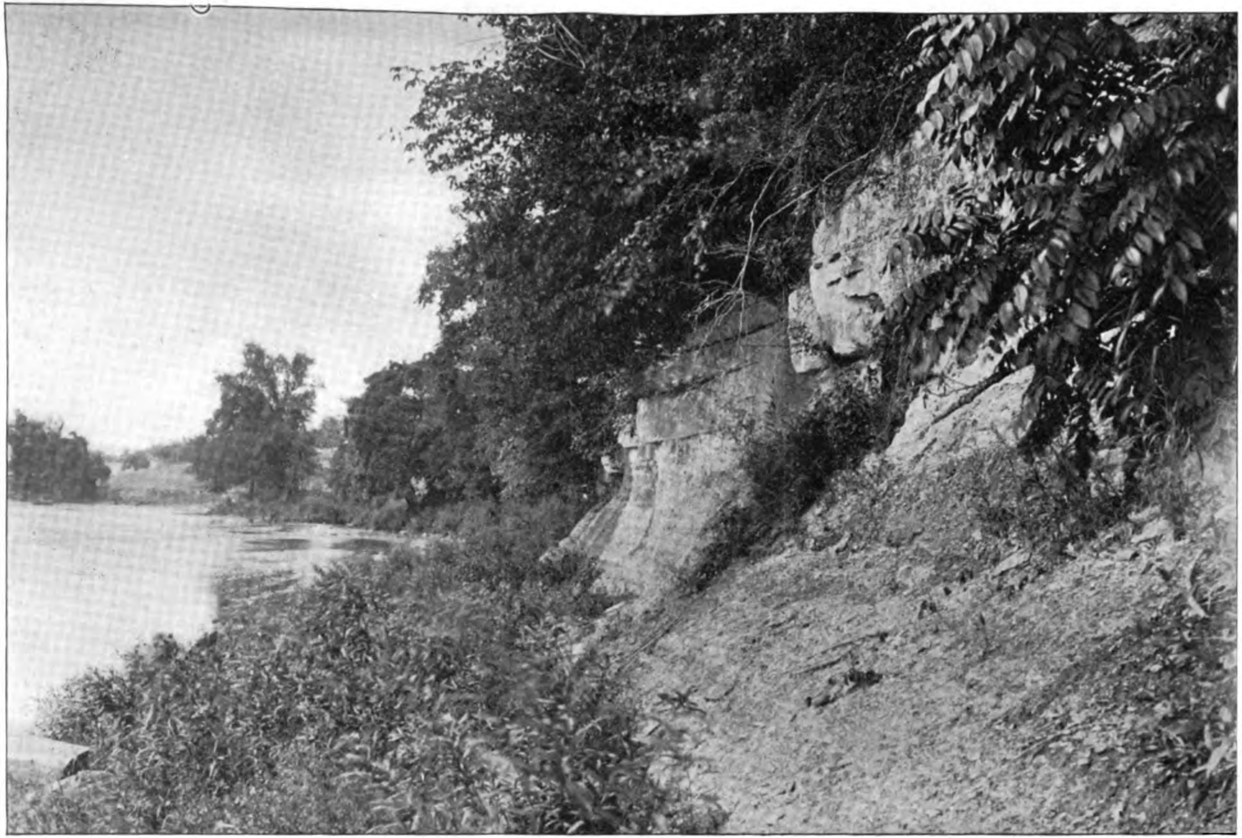
The Cobleskill limestone

Resting immediately on the Brayman shales in the Schoharie valley we find a heavy bedded, semicrystalline, fossiliferous limestone, in places largely composed of fragments of shells, crinoids and corals and with the texture of a sandrock, while other portions are more muddy, consisting largely of impalpable waterlimes. The formation has been most thoroughly studied by Mr C. A. Hartnagel to whose important paper the reader is referred for details.[2] This bed has long been known as the "Coralline

[1] *Loc. cit.* p. 114–15.

[2] Preliminary Observations on the Cobleskill ("Coralline") Limestone of New York, by C. A. Hartnagel. N. Y. State Paleontol. An. Rep't for 1902; N. Y. State Mus. Bul. 69, p. 1109–75.

Plate 5



Brayman shale capped by Cobleskill limestone near the Pyrite mine on west bank of Schoharie creek. Looking south

limestone," which name was given to it by John Gebhard Esq., who early in the 19th century began the study of the formations of the Schoharie region. Till recently it has been regarded as the eastern extension of the Niagara formation of western New York, under which designation it is referred to in all American textbooks of geology and in geologic literature generally. The fossils of this rock were described by Prof. James Hall in 1852,[1] 25 species being recognized in all. Though the fossils resembled only in a general way those found in the typical Niagara beds of western New York, yet this resemblance together with the fact that it was the only fossiliferous limestone between the Lorraine shales and the waterlimes, was considered sufficient to gain acceptance for this correlation. The recent investigations in the stratigraphy of the State of New York, carried on largely under the direction of the present head of the survey, Prof. John M. Clarke, have thrown a flood of light on the difficult problems of the correlation of beds within the State. It became apparent that the time-honored correlations of the Coralline with the Niagara could no longer be held and that the Coralline limestone represented a distinct and not hitherto recognized member of the New York Siluric series. Since the name Coralline was inappropriate as a formation name, that of Cobleskill was substituted for it by Professor Clarke, by which name this formation will henceforth be known. The finding of a Cobleskill fauna above the Salina waterlimes in the Niagara region (North Buffalo), though its significance was at first misunderstood, established a definite scale of succession in a region where sedimentation had been continuous and uninterrupted.[2] The problem was finally attacked by Prof. Charles Schuchert and Mr C. A. Hartnagel from different points and though their conclusions are dissimilar in some respects, the main fact of the Postsalina age of the Cobleskill limestone was clearly demonstrated by both.

[1] Pal. N. Y. 2:321–38, pl. 72–78.

[2] Grabau, A. W. Siluro-Devonic Contact in Erie co. N. Y. Geol. Soc. Am. Bul. 11:347–76.

The best exposure of this rock is on the road along the left bank of the Cobleskill and a short distance west of Howes Cave [pl. 4]. Here the rock is seen capping the Brayman shales, with a thickness of about six feet, and is in turn succeeded by the cement beds of the Rondout. As before stated the line of contact between the Brayman shale and the Cobleskill is marked by a somewhat conglomeratic layer, indicating a certain amount of wave activity. The Cobleskill itself is a normal lime sand-rock, more or less crinoidal, and showing a certain amount of crystalline character. The main portion of the rock consists of fragments of shells and crinoid joints, with masses of coral scattered through them, these latter not uncommonly overturned. From below the limestone, springs issue at several points, some of them forming deposits of calcareous tufa over the underlying shales.

Another good locality for seeing the contact of the Brayman shales and the Cobleskill is at the old pyrite mine, a short distance south of the Gebhard bridge across the Schoharie [map: IX l, 45]. The Cobleskill is seen capping the Brayman shales, and shows here a marked jointing, which causes the rock to split into long and narrow blocks, the width of which is often much less than the thickness [pl. 6]. Several exposures of the Cobleskill are seen in the face of Dann's hill and West hill north of this point, one easily accessible being at the mouth of Clark's cave, or Gebhard's cave as it is commonly called [*see* p. 254]. The Cobleskill is well exposed at the head of the shorter of two streams between Howes Cave and Central Bridge [map: VII h, 19] where it causes a fall, owing to the undermining of the Brayman shale. Large fallen blocks here show the massive character of the bed. In the hillsides of this vicinity the bed crops out and again northward from here on the road to Grovenor Corners above Central Bridge. The bed is again seen in the hillside east of Schoharie. It appears first on both sides of the street leading east from Schoharie postoffice; on the south of the road it crops out in ledges while just north of the road it was formerly quarried in the old Brown quarry [for sec-

Plate 6

Brayman shale capped by Cobleskill limestone at the Pyrite mine

tions here see p. 237]. The thickness of the Cobleskill at the latter point is 5 feet and 4 inches according to the measurements made by Mr Hartnagel. Northward from this the Cobleskill can be traced in the hillside and along the road as far as Mix and O'Reilly's quarry at the stone-crusher in the northeastern part of the village [map: XI c, 42]. In none of these places, however, is the rock readily accessible except at the Brown quarry. There are a few other exposures north of the stone-crusher along the west face of East hill, the best one, by far, being that on the hillside just south of Seth Stevens's house at Shutters Corners [map: XIII-i, 40]. To reach this, follow the road behind the Stevens house uphill to where you see on the right a clump of bushes across a field. Here the ledges are found which have yielded the richest collections of Cobleskill fossils, Mr Hartnagel's list including 45 species. This investigator concludes that "the appearance of the coral masses in this rock . . . indicates that this was their original place of growth; and thus a locality favorable for the existence of these types of life . . .[1] He found Trochoceras gebhardi and large gastropods resting on the summit of the coral heads, and that these shells in turn served for the attachment of new corals and coralline growths which often embedded the shells. In the lower portion of the rock is a bed containing an abundance of Chonetes jerseyensis Weller. The characteristic Niagara trilobite Calymmene niagarensis has been found associated with these fossils.

From the abundance of the corals at this point it seems not unlikely that we have here one of the local coral reefs which have supplied much of the lime-sand and mud from which the main mass of the Cobleskill was built up. In the more evenly stratified portions of the other exposures the corals are more often fragmentary, being worn or dissolved, and rolled about considerably before they were embedded in the lime-sand matrix. It is somewhat surprising that more actual Cobleskill reefs have not been discovered.

[1] *Loc. cit.* p. 1118.

Of the 60 species listed by Hartnagel from the Cobleskill of Schoharie county a comparatively limited number may be regarded as diagnostic of the formation. Among the corals and hydrocorallines the genera Favosites and Stromatopora must be regarded as of chief importance. The former is represented by a species intermediate between F. niagarensis and F. helderbergiae, which was described by Schuchert as a variety of the latter under the varietal name precedens [fig. 7]. Its chief distinction is in the smaller size of the heads.

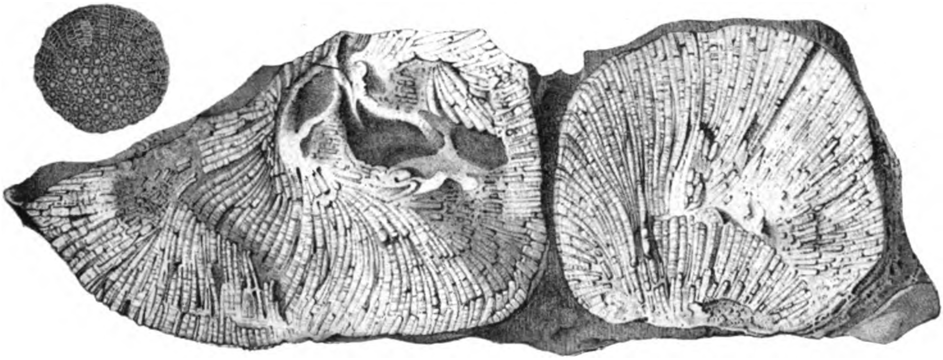


Fig. 7 Favosites helderbergiae precedens. Fragment of rock with section of heads, one reversed and one normal. Polished section of small head

Among the brachiopods may be mentioned Orthothetes interstriatus [fig. 8], a small finely striated species; Chonetes jerseyensis [fig. 9] characterized by curved striae in the adult; Spirifer corallinensis [fig. 10] and S. eriensis [fig. 11], both small species, the former with obsolescent, the latter with few coarse rounded plications; Whitfieldella nucleolata [fig. 12], a small smooth and nearly circular species; Camarotoechia ? lamellata [fig. 13], a broad species with deep sinus and lamellose striae; and Camarotoechia litchfieldensis, [fig. 14], a more robust form, with fewer and coarser plications.

Among the pelecypods, Pterinea securiformis and Tellinomya equilatera [fig. 15] are most abundant. The former is a large smooth aviculoid, the other a nearly sym-

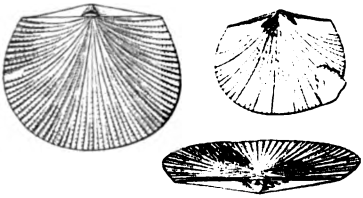


Fig. 8 Orthothetes interstriatus

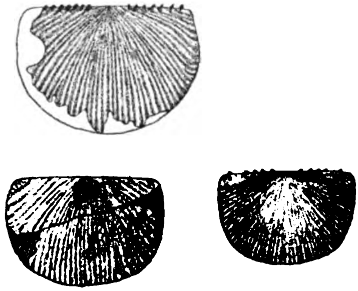


Fig. 9 Chonetes jerseyensis

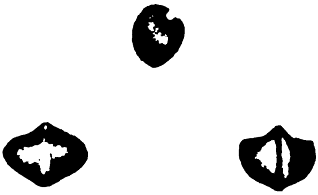


Fig. 10 Spirifer corallinensis

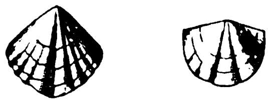


Fig. 11 Spirifer eriensis

Fig. 12 Whitfieldella nucleolata

Fig. 13 Camarotoechia lamellata

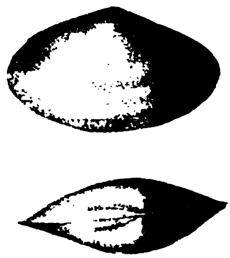


Fig. 15 Tellinomya equilatera

Fig. 14 Camarotoechia litchfieldensis

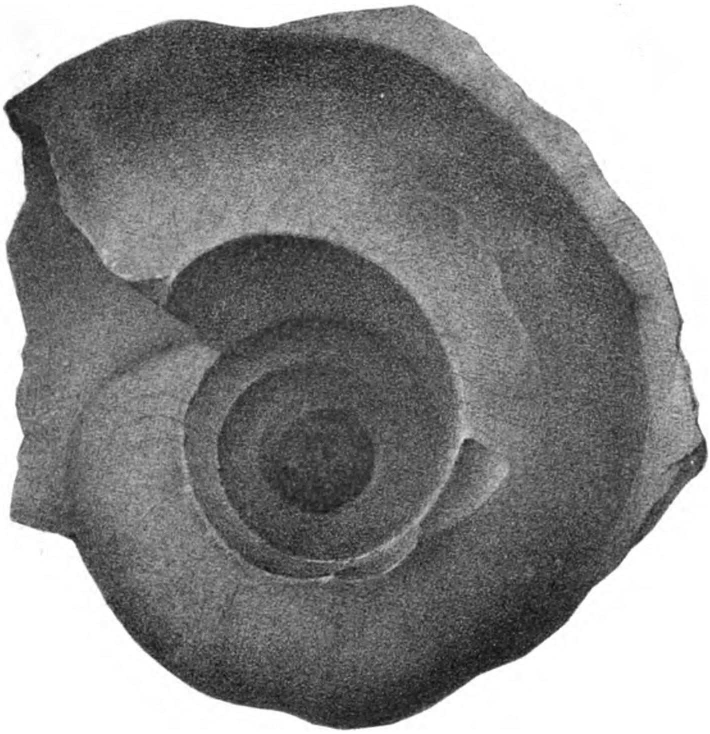


Fig. 16 Trochoceras gebhardi (from below)

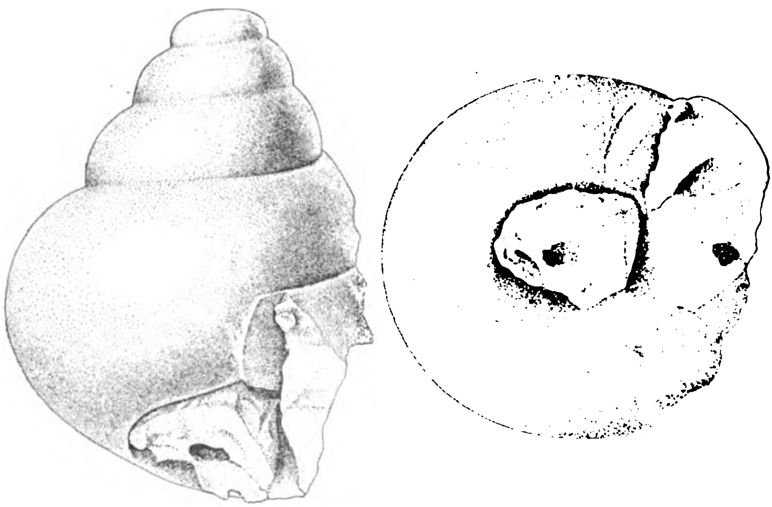
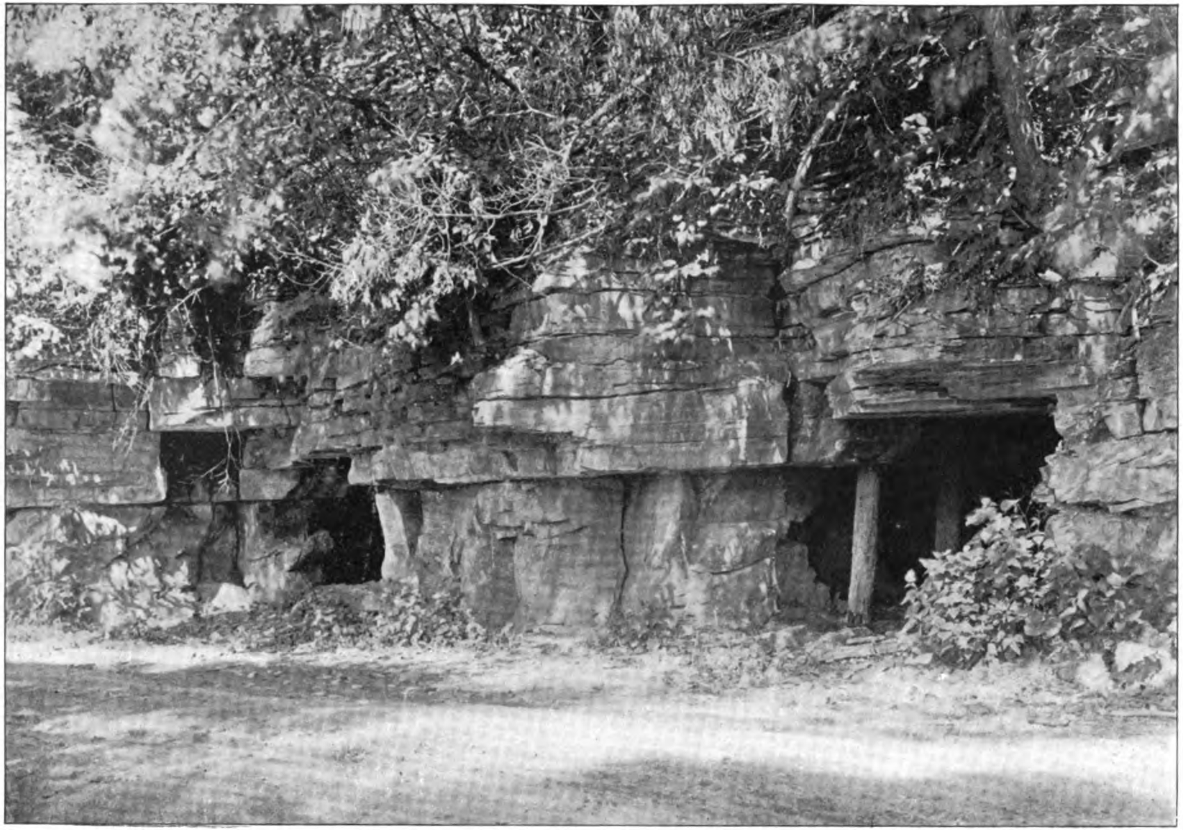


Fig. 17 Trochoceras gebhardi, two thirds natural size

Plate 7



Cement quarries in Rondout waterlime. Howes Cave

metric bivalve. The cephalopods are represented by Trochoceras gebhardi [fig. 16, 17] which coils so as to resemble a large gastropod. Crustacea are represented chiefly by the two large species of ostracods Leperditia jonesi and L. scalaris [fig. 18], the latter with a swelling on the hinge margin not found in L. jonesi. Trilobites (Calymmene, Dalmanites, Lichas etc.) are also found.

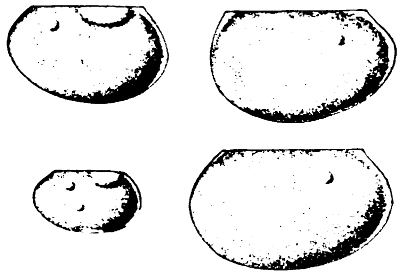


Fig. 18 Leperditia scalaris (enlarged)

The Rondout and Manlius limestones

The Cobleskill bed is succeeded by a series of more or less uniformly and finely bedded lime mudrocks with occasional lime sandrocks which form a deposit averaging 60 feet in thickness in the Schoharie region. The name Rondout limestone is applied to the lower portion from the extensive cement-mining operations which are carried on in this formation near Rondout N. Y. At that locality the upper beds included in the formation are not used for cement. They show a remarkable series of mudcrack structures of pentagonal form which very clearly indicate that this rock was a fine lime mud, probably exposed at low tide to the drying influence of the sun. Though not common at Schoharie this structure has been found in blocks of Rondout limestone on West hill.

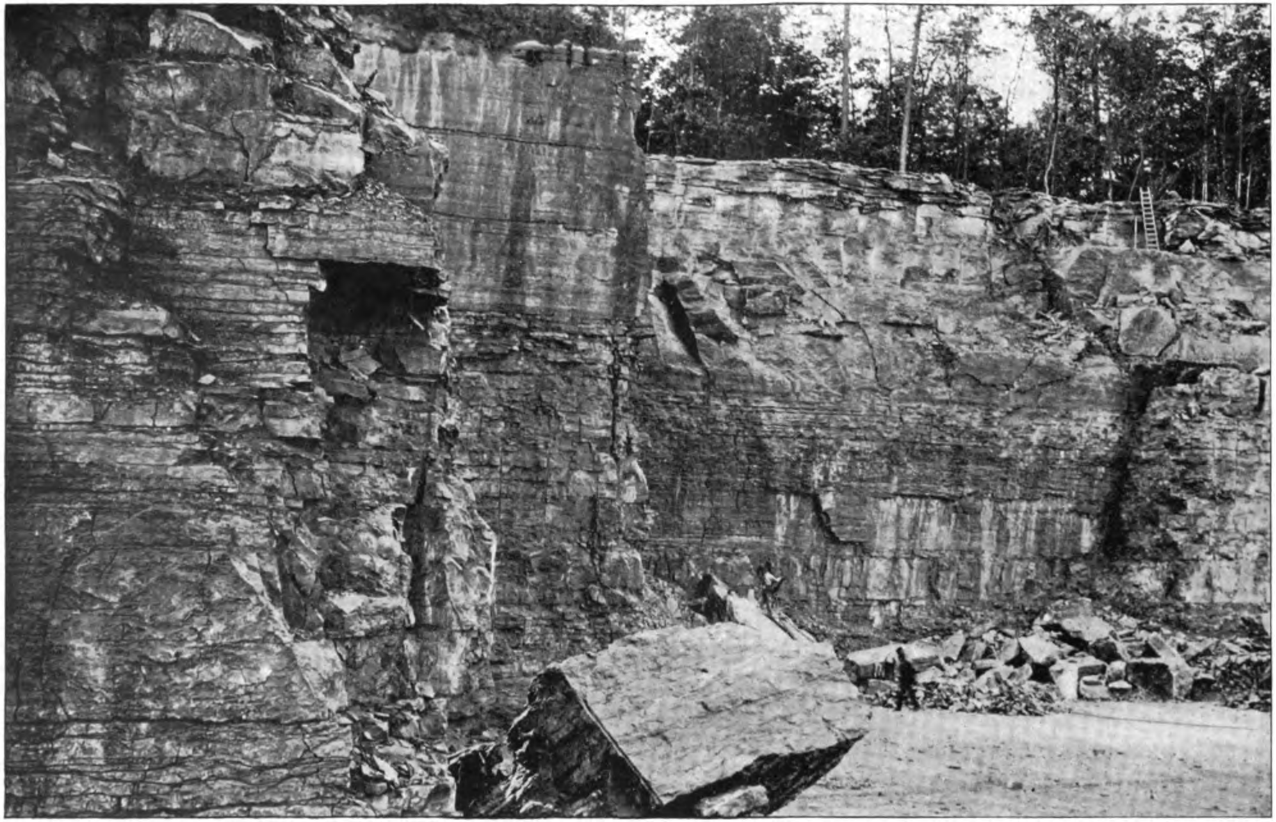
The only place in the Schoharie region where the cement beds of the Rondout are mined is at Howes Cave. Here the lowest 6 feet of the Rondout formation are mined in tunnels by the Helderberg Cement Co. for the manufacture of natural or Rosendale cement [pl. 7]. The application of the latter term to the cement here mined is merely a commercial practice; the bed mined is not the stratigraphic equivalent of the Rosendale cement bed (the lower bed mined at Rosendale) but of the upper or the one to which the name Rondout is applied. At Howes Cave

the rock is a banded lime mudrock, rather massively bedded and breaks with a conchoidal fracture. It is bluish gray when fresh but weathers brownish. In the lower portion are fragments and small heads of Favosites helderbergiae var. precedens [fig. 7], which have passed up from the Cobleskill. Above the cement bed are 42 feet of strata, mostly lime mudrocks, but with frequent layers of a more arenaceous texture. Many of the beds are very shaly, partaking almost of the character of paper shales and containing a considerable amount of argillaceous material. On weathering they leave much clay behind. These beds are considered worthless in the manufacture of cement. They are succeeded by 43½ feet of Manlius, which is here quarried for Portland cement, containing on the average from 93 to 94% of calcium carbonate. The beds are mostly thin and irregularly bedded calcareous mudrocks, the lowest portion being of the type often called ribbon limestones. They are similar to the underlying beds but of a purer composition. A few heavy bedded, somewhat more arenaceous layers occur which are known by the name of "curly" layers.[1] The thinner bedded strata are often rich in Tentaculites gyracanthus [fig. 25] and Spirifer vanuxemi [fig. 24] and Leperditia alta [fig. 24a] are also common in some layers [pl. 8, 20].

The term Manlius was applied by Clarke and Schuchert to the uppermost formation of the Siluric, which has long been known by the name of Tentaculite limestone, from the abundance of the small pteropod, Tentaculites gyracanthus, which often covers the weathered surfaces of the slabs of this rock. It is chiefly a rock composed of impalpable lime mud. Most of the beds are very firm and when struck with a hammer emit a ringing sound. There are usually alternating heavy strata, in which fossils are rather rare, and thin bedded layers, in which the three fossils Tentaculites gyracanthus, Spirifer vanuxemi and Leperditia alta are common, though gener-

[1] *See* section p. 259.

Plate 8



Helderberg Cement Co.'s quarry. The lower thin bedded limestones are the Manlius, the upper heavier bedded strata the Coeymans [see pl. 20]

ally only one of these species is abundant on a given slab of the rock. At intervals beds of a more arenaceous texture occur, the material being a moderately coarse lime sand. Such beds show much less of even bedding than do the mudrocks, and ripple marks, cross bedding and other features so characteristic of silicious sandrocks, are found, though the rock is entirely free from quartz grains. Shaly beds, or beds of more or less calcareous clay mudrock also occur, though not very commonly nor of great extent. They generally fill the interstices between lens-like masses of lime sandrocks or lime mudrocks.

In the Schoharie valley the best exposures of the Rondout and Manlius beds are in the various quarries opened along the base of East hill, east of the village of Schoharie.[1] The lowest beds of the series, i. e. those following immediately on the Cobleskill, are best exposed in the Vrooman quarry, southeast of Schoharie post-office. They are heavy bedded lime mudrocks, occasionally showing a somewhat arenaceous texture, and containing worn fragments of Favosites and Stromatopora. Complete heads of these corals are also found in the more argillaceous parting shales. The next higher beds are found in the Becker quarry below Laselle park, just east of Schoharie and in the lower Mix and O'Reilly quarry at the stone crusher in the northeastern part of the village. Here the thickness of the Rondout formation has been reported to be 17 feet [pl. 8, 16].[2]

In this locality some of the massive beds of the Rondout series contain scattered geodes of calcite and of celestite. These geodes are found occasionally in the stone fences in the northeastern part of the village, and they are also well shown on the northern face of West hill, where mining operations for the strontium mineral were formerly carried on for some time.

The higher Rondout beds are shown in the Mix and O'Reilly quarry where they are succeeded by the fossiliferous Manlius. These Manlius strata are also shown in the Becker quarry and in the old quarry behind the cemetery east of Schoharie courthouse.

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[1] For the details of these sections *see* chapter 5.

[2] *See* section ch. 5, p. 239.

From the top of the Mix and O'Reilly quarry, transitional beds from the Manlius to the Coeymans extend to the foot of the Coeymans ledge which crops out in the wood behind the cemetery. These beds are covered in the interval, but are well shown in the quarry next south in the hillside, where the Coeymans is also quarried for road metal.

The total interval from the top of the Cobleskill to the base of the transition beds is 59 feet, 6 inches. The transition beds which may be classed with the Manlius, since they partake more of the character of this rock than of the Coeymans, have a thickness of 12 feet and 6 inches, making a total for the Rondout and Manlius limestones at Schoharie of 72 feet. This is somewhat less than the measurement at Howes Cave, where the same formations have a combined thickness of 91 feet. This appears to be due to the more argillaceous character of the lower or Rondout beds of the series at Howes Cave, though similar argillaceous beds are found in the outcrops on West hill and presumably exist in the covered portions of this formation in Schoharie.

The fauna of the transition beds is very interesting, since it represents oscillating conditions between the Manlius and the Coeymans. They contain at intervals a pure fauna of Spirifer vanuxemi [fig. 24] and Tentaculites, or again beds with abundant Stropheodonta varistriata [fig. 23], and others with a variety of Camarotoechia semiplicata [fig. 27], with a very angular anterior portion, and other typical Helderbergian species.

The number of fossils characterizing the Rondout and Manlius in this region is not very great. Some of the corals and brachiopods of the Cobleskill extend upward into the Rondout and some even reappear in the Manlius limestone. Among these are Favosites helderbergiae var. precedens, Stromatopora cf. antiqua, Camarotoechia lamellata [fig. 13] Spirifer eriensis [fig. 11] and S. corallinensis [fig. 10]. There are no Stromatopora beds in the Manlius of this region as there are in the Hudson valley. At

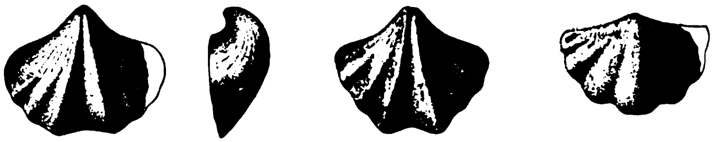


Fig. 19 Spirifer eriensis var.

Fig. 20 Spirifer corallinensis, pedicle valve

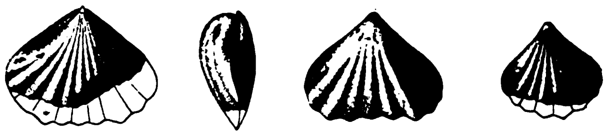


Fig. 21 Camarotoechia hudsonica

Fig. 23 Stropheodonta varistriata

Fig. 24a Leperditia alta

Fig. 22 Stromatopora *cf.* antiqua

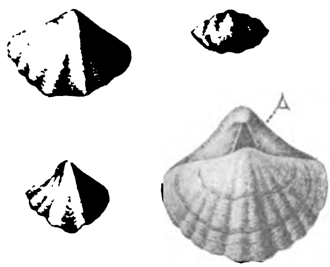


Fig. 24 Spirifer vanuxemi

Rondout two beds filled with heads of Stromatopora occur between $12\frac{1}{2}$ and $25\frac{1}{2}$ feet below the top of the formation. Associated with these is a rich gastropod fauna of which a partial list is given by van Ingen and Clark in their report on that region.[1] Similar beds are found in the upper part of the Manlius at Becraft mountain, the uppermost of which lies just below the Coeymans limestone. This highest Stromatopora bed was

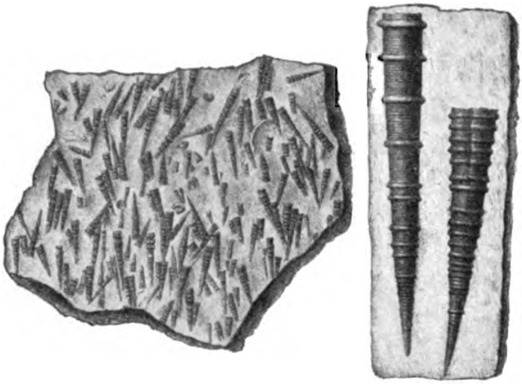


Fig. 25 Tentaculites gyracanthus

found to contain a modified Cobleskill fauna, with Spirifer eriensis var. [fig. 19], Sp. corallinensis [fig. 20] and Camarotoechia hudsonica, [fig. 21], the latter a close relative of C. litchfieldensis, predominating. It is interesting that the first two species are not recorded from the Cobleskill of the Hudson valley, though they are abundant and characteristic of this formation in the Schoharie valley and westward.

The thickness of the combined Rondout and Manlius formations along the Helderberg escarpment is as follows: Rosendale about 55 ft; Rondout $61\frac{1}{2}$ ft; Becraft mountain 57 ft; New Salem $51\frac{1}{2}$ ($6\frac{1}{2}$ ft being waterlime at the base); Indian ladder 51 ft ($4\frac{1}{2}$ ft of the basal portion belonging to the Rondout);

[1] N. Y. State Paleontol. An. Rep't for 1902; N. Y. State Mus. Bul. 69, p. 1183.

Altamont 40 ft [1 to 2 ft at base may be Rondout]; Schoharie 72 ft; Howes Cave 91 ft. In the sections at Becraft mountain, New Salem, Indian Ladder and Altamont the diminished thickness is due to the absence of several members near the base, there being an overlap of the higher members which come to rest on the Lorraine.

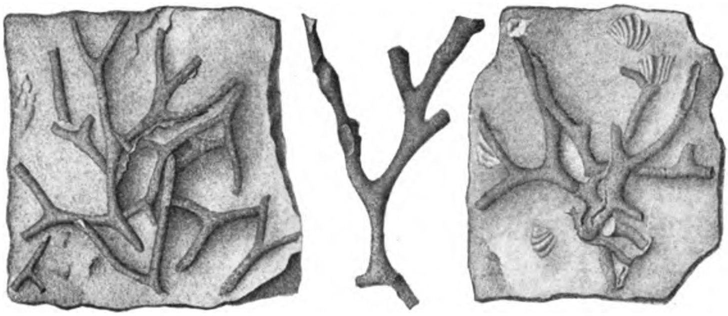


Fig. 26 Monotrypella? arbusculus

The more characteristic fossils of these two formations are as follows:

Corals and hydrocorallines: Favosites helderbergiae var. precedens [fig. 7] and Stromatopora cf. antiqua [fig. 22], species which have already been noted under the Cobleskill.

Brachiopods: Stropheodonta varistriata [fig. 23], a small nearly flat species with fine striae which are sometimes strongly alternating, and Spirifer vanuxemi [fig. 24], characterized by few but pronounced plications. Two other common fossils are the pteropod Tentaculites gyracanthus [fig. 25] and the small smooth bivalved ostracod Leperditia alta [fig. 24a], which sometimes covers the surface of the slabs. A small branching bryozoan Monotrypella? arbusculus [fig. 26] also occurs at times in considerable abundance.

Description of Camarotoechia semiplicata (Conrad) var. angulata var. nov. as represented in the Transition beds [fig. 27 a–h].

Shell subtriangular in outline with the valves nearly equally and moderately convex. Pedicle valve with the beak overarching that of the brachial valve, more strongly arched in the posterior than in the anterior portion. Greatest width about two thirds the distance from the beak to the anterior margin.

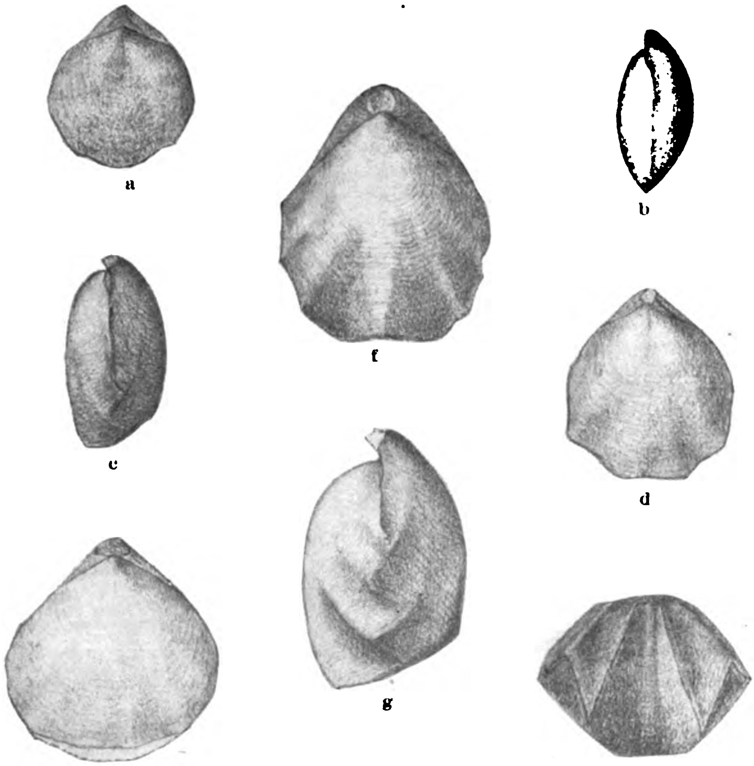


Fig. 27 Camarotoechia semiplicata var. angulata var. nov. (much enlarged)

Anterior third to half only, marked by broad rounded plications, which become angular toward the front in the adult. These plicae arise gradually from the nonplicate surface. Two plications near the center border a narrow median depression in which there is a median faint, rounded plication. Two to three fainter plications occur outside those bounding the sinus, on each side.

Brachial valve scarcely less arched than the pedicle valve, with a median longitudinal flattening or faint depression on the smooth portion. Anterior portion alone marked by a rather pronounced median elevation which is gently grooved at the center. Three rounded marginal plications occur on either side, decreasing in size away from the center and becoming pronounced and angular toward the front in the adult shell.

Surface marked by fine lines of growth which are faint on the smooth umbonal portion but lower down including equidistant stronger ones, which give the surface a lamellose aspect. Faint radiating lines are visible.

A young specimen $\frac{7}{30}$ inch long [fig. 27 c, d] has the plications just appearing in the form of a wavy margin. The brachial valve in this is less convex, rather flattened and marked by a median depression. A slightly younger shell is perfectly smooth except for the well developed concentric striae [fig. 27 a, b].

In adult individuals [fig. 27 f–h] the plications are strong and angular at the front and the median depression profound with the central plication in it rather strong.

A comparison with specimens from the Coeymans limestone shows this variety to be narrower, thicker, with a more sharply depressed sinus, in which the fold is less pronounced, and with more angular plications. The difference is shown by the following measurements of two characteristic specimens.

	TRANSITION VARIETY	COEYMANS VARIETY
Length	5.5 mm	6.5 mm
Width	4.5 mm	6 mm
Depth	3.7 mm	3.5± mm

The Rondout and Manlius are the cavern formations of the region, for in them are found Howes cave on the Cobleskill; Ball's cave on Barton hill (though here the entrance is through a fissure in the overlying Coeymans), Clark's or Gebhard's cave,

the mouth of which is just above the Cobleskill, and Becker's cave below Lasell park, the entrance to which is in the Manlius above the waterlime. Numerous other caves occur in this rock in eastern New York. Caverns are much less frequent in the coarser grained limestone, though fissures of considerable width are common. They generally open to the surface however. It seems that the lime mudrocks are more readily dissolved than the lime sandrocks which generally are more or less crystalline and that furthermore the thin bedded character of the rock is more favorable to the passage of underground water than is the coarse massive-bedded lime sandrock of the higher formations.

In the western part of the State of New York the Siluric (Ontaric) section is as follows, the thicknesses given being those found in the Niagara section.

Devonic Onondaga limestone

Hiatus

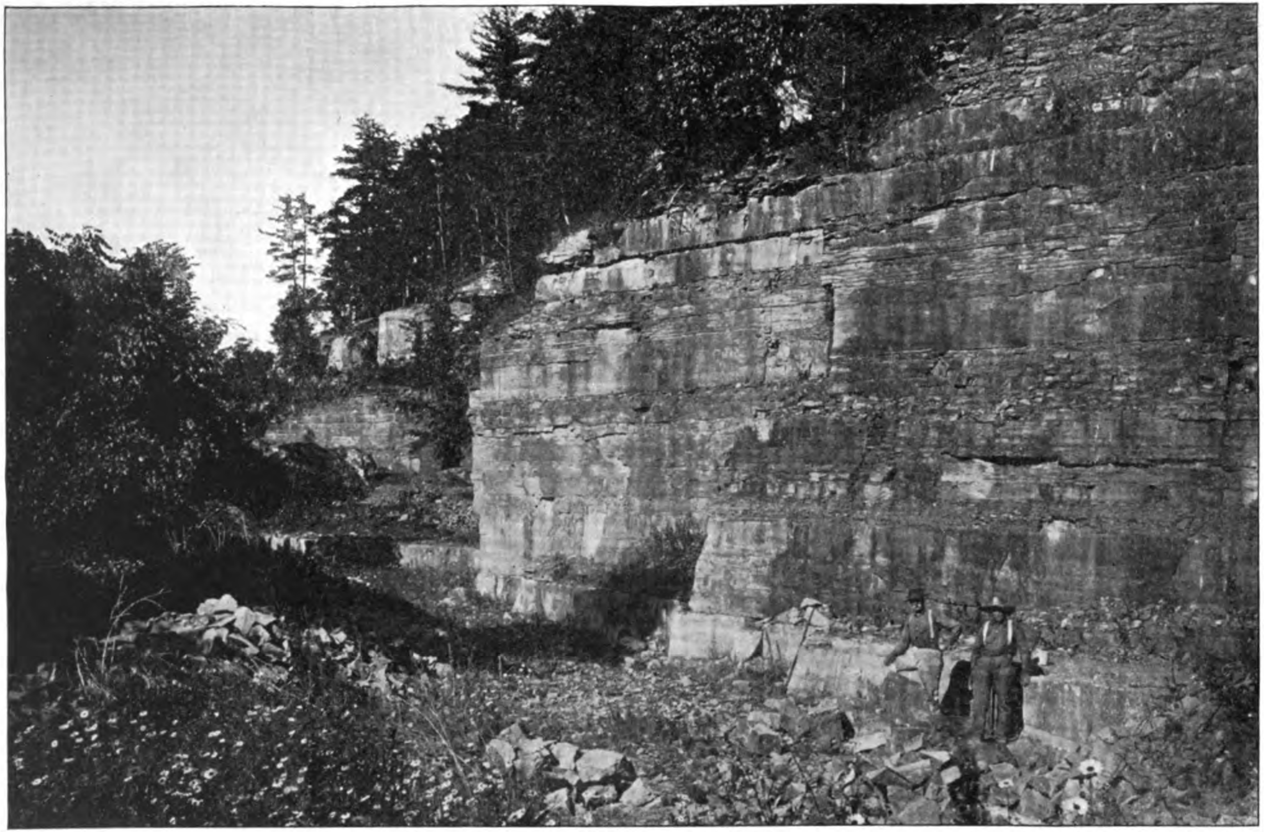
			FEET
iluric or Ontaric	Cayugan	Cobleskill[1] (Bullhead) limestone..	7-8
		Bertie waterline	60
		Camillus shale	150
		Syracuse beds.	35
		Vernon shale Pittsford shale	200
	Niagaran	Guelph dolomites Lockport dolomite	200
		Rochester shale	75
		Clinton beds..................	40
	Oswegan	Medina sandstones......	125±
		Medina shales and sandstones....	1140±
		Oswego sandstone	75±

Champlainic Lorraine shales

In central New York the Oswego sandstone merges into the Oneida; a pure white quartz pebble conglomerate. At Washington Mills, Oneida co. this conglomerate rests directly on the

[1]The name Greenfield limestone has been used by the author for this western type of the Cobleskill, from Greenfield O., where it is well developed. Science, Dec. 2, 1898. v.8, no.205. p.800.

Plate 9



Becker's quarry looking north. The Manlius limestone is quarried here. The transition beds are shown in the upper right hand portion of the picture [*see* pl. 18]

Lorraine shales, the succession being an abrupt one. The source of the pebbles of this conglomerate could only have been in the crystalline highlands, i. e. the Adirondacks, and the Appalachian protaxis of New York, Pennsylvania and the Southern States, for we know of no other source for the quartz pebbles than these crystallines. That all the material except the indestructible quartz has been removed, indicates that these beds must have been repeatedly worked over by the waves. The sudden succession of these conglomerates on the soft shales in central New York is explained by the condition outlined in chapter 1. A stationary or a gently rising sea floor will cause the shore to migrate seaward and carry with it the shore deposits which will gradually creep out over the sand deposits of what was formerly deeper water. If the recession of the shore is a slow one the thickness of the shore deposit, i. e. the conglomerate, is mostly uniform. On the other hand a rapid recession of the shore will result in a progressively thinner and thinner accumulation of the shore deposits over the deeper water beds.[1]

If we picture to ourselves the condition of deposition during Lorraine time, we must realize that the edge of the Lorraine sea touched the crystalline shore, from which the sands and clays were derived. That being the case the Lorraine deposits naturally overlapped the preceding Champlainic deposits, a result we would expect where a progressive subsidence of the sea bottom takes place. Along the shore the deposits must have been conglomerates and coarse sandstones and at intervals some of these must have spread out over the finer deposits, thus giving us the abrupt alternations commonly seen [fig. 28A]. At the end of Lorraine time, a gradual rise of the shore and a consequent retreat of the sea margin appears to have taken place, accompanied in the Appalachian region by considerable folding and

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[1] Rivers from the rising Green mountain chain no doubt formed a powerful agent aiding the waves in carrying the pebbles westward and in thoroughly rounding them. The red sands and muds of the Medina, derived from the oxidized crystallines were probably also in part subaerial in origin.

crumpling.[1] This resulted in a westward migration of the shore and a consequent working over of the Lorraine shore deposits and their gradual westward spread over the soft Lorraine beds, constituting some of the beds referred to the Oneida conglomerate which farther out merge into the Oswego sandstone. It is highly probable that during this time, i. e. while the Oswego beds were creeping out westward, the highest Champlainic beds of the

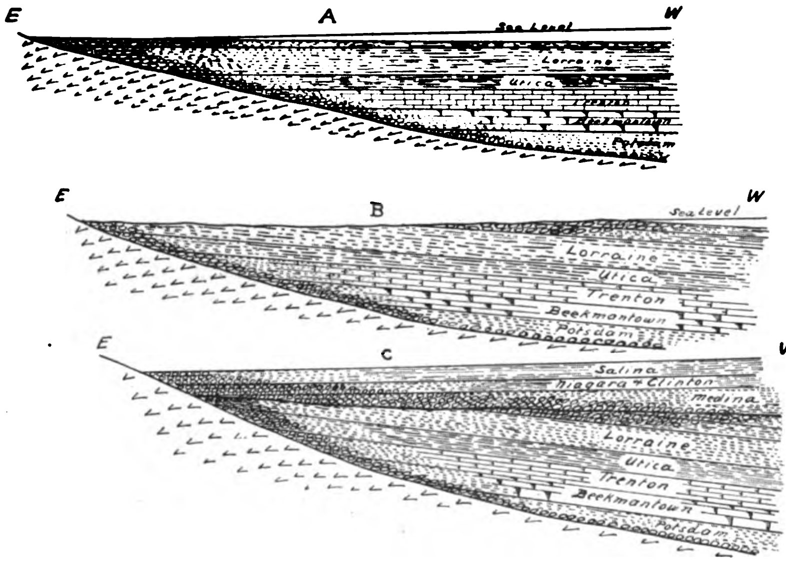


Fig. 28 A–C A Diagram of the strata of New York at the beginning of Upper Siluric time; B at time of maximum retreat of the sea; C at end of Salina time.

interior, i. e. the Richmond shales were deposited [fig. 28B]. By the time that Oswego deposition had been completed the eastern shore was well out of water, and the Lorraine and earlier strata of that region were undergoing folding and erosion simultaneously. When the shore had migrated westward to the limit indicated by the extent of the conglomerates, a reversal of conditions

[1]The student must be careful here not to confound this crumpling with the later folding of the strata which has produced the Appalachians. The folding here spoken of affected only the Lorraine and earlier beds and occurred before the deposition of the Siluric and later beds. It resulted in the formation of the Green mountain chain, and is hence commonly spoken of as the Green mountain revolution.

took place, subsidence of the sea floor and consequent advance of the shore taking the place of elevation and retreat of the shore. This advance of the shore brought with it a second working over of the conglomerates which gradually crept on to the shore again, covering the previously eroded surfaces. While this took place the finer material, much oxidized, was carried seaward, i. e. westward, and deposited above the Oswego sandstone as the red Medina mud, which now constitutes the shale 1100 feet thick in western New York. Now, while the deposition of these shales went on the shore gradually advanced and with it the conglomerates. But obviously these advancing conglomerates, though continuous with the Oneida conglomerate, became of later and later age, and corresponded in time to the red Medina shales of western New York [fig. 28C]. It is thus evident that these later conglomerates can not be called the Oneida, as is generally done, since they are of Postoneida age. The term basal conglomerates or Shawangunk conglomerate, the latter being applied to a portion of the basal conglomerate in the Shawangunk mountains, which is most certainly of Salina age, may be used in a general discussion of this lithic but not stratigraphic unit. Toward the end of the deposition of the 1100 feet of Medina shales there was another spreading out of the shore strata, which caused the formation of the quartzose bed that abruptly overlies the Medina shales at Niagara.[1] Then came the deposition of the Medina sandstones, which indicates shallow water, an idea borne out by the ripple marks and wave marks on these rocks. To the west of Lake Michigan the Medina and Oswego are both absent or but slightly represented. This may be due to the existence of land conditions in that region, in which case we should expect shore deposits in the thin western edge of the Medina. Or the Mayville lime sandrock may have accumulated during Medina time in the western purer water. This seems

[1] *See* Geology and Paleontology of Niagara Falls and Vicinity. N. Y. State Mus. Bul. 45. 1901. p.88.

a not unlikely case, as this limestone, so far as known, follows conformably on the upper Champlainic strata.[1]

Even at the typical locality in Oneida county the conglomerate appears to be not earlier than the Medina but rather the equivalent of the upper Medina, corresponding in age to a part of the upper hundred feet of the Medina of western New York. At least this is true of the upper part of this conglomerate which appears to belong to the advancing instead of the retreating shore line phase. This is indicated by the fact that the Medina sandstones overlying the conglomerate are less than 100 feet thick in Oneida county. It is true, of course, that we may have a slower subsidence here than in western New York and therefore a smaller deposition. If that is the case, we might expect coarser deposits, unless indeed the shore by this time was far removed. There might also be an hiatus in the middle of the sandstone series.

In Montgomery and parts of Herkimer counties however, we find a conglomerate between the Clinton and Lorraine with a total absence of the Medina sandstones. Here the conglomerate certainly represents the upper Medina, and belongs to the advancing phase of the Medina seashore. At Rosendale and in the Shawangunk mountains the conglomerate rests on the folded and eroded shales whose age may be Lorraine or earlier.[2] The thickness of the conglomerate is something over 200 feet in the Shawangunk mountains but thins away northeastward, disappearing near Binnewater. Locally the conglomerate often becomes a coarse quartz sand. Above the conglomerate in the Shawangunk region are shales (=High Falls) and sandstones (Binnewater) commonly but erroneously referred to the Medina or Clinton. They

[1] If no unconformity exists between the upper Richmond and the Mayville beds and if the latter are of the age of the Clinton of New York, the lower Medina shales of the Niagara region resting upon the Lorraine, must be of Richmond age. The upper Medina, however, has a marine fauna closely linking it with the Clinton.

[2] The Champlainic is almost wholly represented by shales and sandstones in the northern Hudson valley. These shales are the Hudson shales in the modern acceptation of the term, their age ranging from Upper Cambric (Dictyonema beds) to Lorraine.

average 40 feet in thickness in the cement district, but south of Rosendale give way to argillaceous and ferruginous sediments (Longwood shales). The sandstone phase of this series overlaps the conglomerate north of Binnewater, indicating a more rapid subsidence which prevented the formation of the conglomerate. The highest bed of the series, a white quartzite, laps over all the lower ones, appearing as far north as Wilbur bridge across the Rondout, where it rests directly on the Hudson river slates. This formation appears thus to be much later than the Clinton and if the conglomerate is early Salina, this bed too is Salina. It is followed by the Salina waterlimes (Rosendale bed) with an abrupt succession indicating a rapid or even sudden subsidence, so that only the fine calcareous muds of which these rocks are composed could be deposited. That the surface of the floor formed by these Shawangunk sandstones was not a level one is shown by the varying thickness of the first or Rosendale cement bed, which at Rosendale is 20 feet thick, but at one point near Binnewater thins down to 4 feet, though quickly increasing again. At the West Shore railroad bridge across Rondout creek at Wilbur, the thickness of this lower bed is 10½ feet. In many places the base of the Rosendale cement is formed of a more or less crystalline lime sandrock, a few feet in thickness. This has been called the Wilbur limestone by Hartnagel. It contains a modified Niagaran fauna. Throughout the cement region the Rosendale bed is succeeded by a limestone bed varying from 10 to 15 feet in thickness, which Hartnagel has identified with the Cobleskill limestone. This rock is mostly a lime sandrock with large heads of Halysites catenulatus var. [fig. 29], Favosites niagarensis [fig. 30] and Stromatopora sp., besides brachiopods, many of which are of Niagaran affinities.

Fig. 29 Halysites catenulatus var.

Regarding the identity of the Cobleskill of the cement region as established it becomes apparent that the Brayman shales are the approximate stratigraphic equivalents of the Rosendale cement bed. As before noted however, the indication of an hiatus at the top of the Brayman shales makes absolute equivalency doubtful. The Rosendale cement bed of eastern New York appears also to be the stratigraphic equivalent of the Bertie formation, or at least a part of it in western New York. That formation averages 60 feet

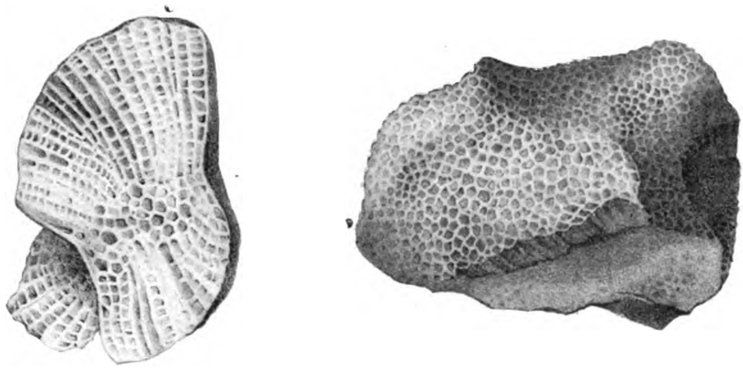


Fig. 30 Favosites niagarensis

in thickness at Buffalo, though only the upper 8 or 10 feet carry the Eurypterus fauna. It is therefore probable that the Rosendale bed corresponds only to the upper part of the Bertie, while the underlying sandstones and conglomerates (Shawangunk beds) probably are the equivalent of the lower part of the Bertie, as well as part of the remaining Salina beds.[1]

[1]The impropriety of considering the Shawangunk grit basal Siluric in age will be apparent when we consider that it rests *unconformably* on the folded Hudson river strata in which are included the Lorraine or Upper Champlainic beds. It would be necessary to assume that the folding and extensive erosion which the Hudson river beds suffered after Lorraine time was all accomplished during the interval represented by the Richmond beds of the west. Thus very little time is allowed for the folding and erosion of the Champlainic beds, if the succeeding beds are considered basal Siluric, i. e., Premedina as is the general practice. If however we consider the Shawangunk grit of Salina age, the folding and erosion of the Champlainic beds could have been accomplished during Palaeo- and Meso-Siluric time.

Under the description of the Brayman shales it has been pointed out that the contact with the underlying sandstone has all the character of a normal conformable contact, there being absolutely no indication in the exposures of a break in the series. Furthermore the sandstones are different in lithic character from those commonly found in the Lorraine and have characteristics in common with the Brayman shales. To place the long time interval between the Champlainic and Upper Siluric at this level seems wholly unwarranted; indeed, the nature of the contact forbids it. We must look lower down for this Siluro-Champlainic contact, and consider the sandstones immediately in contact with the Brayman shales as the equivalent of the Binnewater sandstones in the cement region. That the contact between these sandstones and the Hudson river (Lorraine) beds has not been found need create no surprise when it is remembered that the upper Lorraine beds are also sandstones and that therefore the contact would not be a pronounced one; and furthermore, that there is nowhere in this region a good continuous exposure where this contact could easily be traced.

Northeastward from Schoharie the basal beds progressively thin away. At the Albany county line both the basal sandstones (Binnewater) and the Brayman shales have disappeared, being overlapped by the Cobleskill. At Altamont the Cobleskill is also absent, together with the greater part of the Rondout, only about 2 feet of the latter occurring between the Manlius and the Lorraine. Northward from the cement region of Ulster county a similar dying away of lower and overlapping of higher beds occurs. At Catskill the Cobleskill rests on the Lorraine, while at Becraft the Manlius, or at any rate the upper Rondout beds, rest on the Lorraine. At New Salem 6½ feet of the Rondout occur, separated by a transition basal sandstone of 10 inches which probably represents the arenaceous clastic accumulations on the old erosion surface of Hudson river rocks.[1] At Indian Ladder the

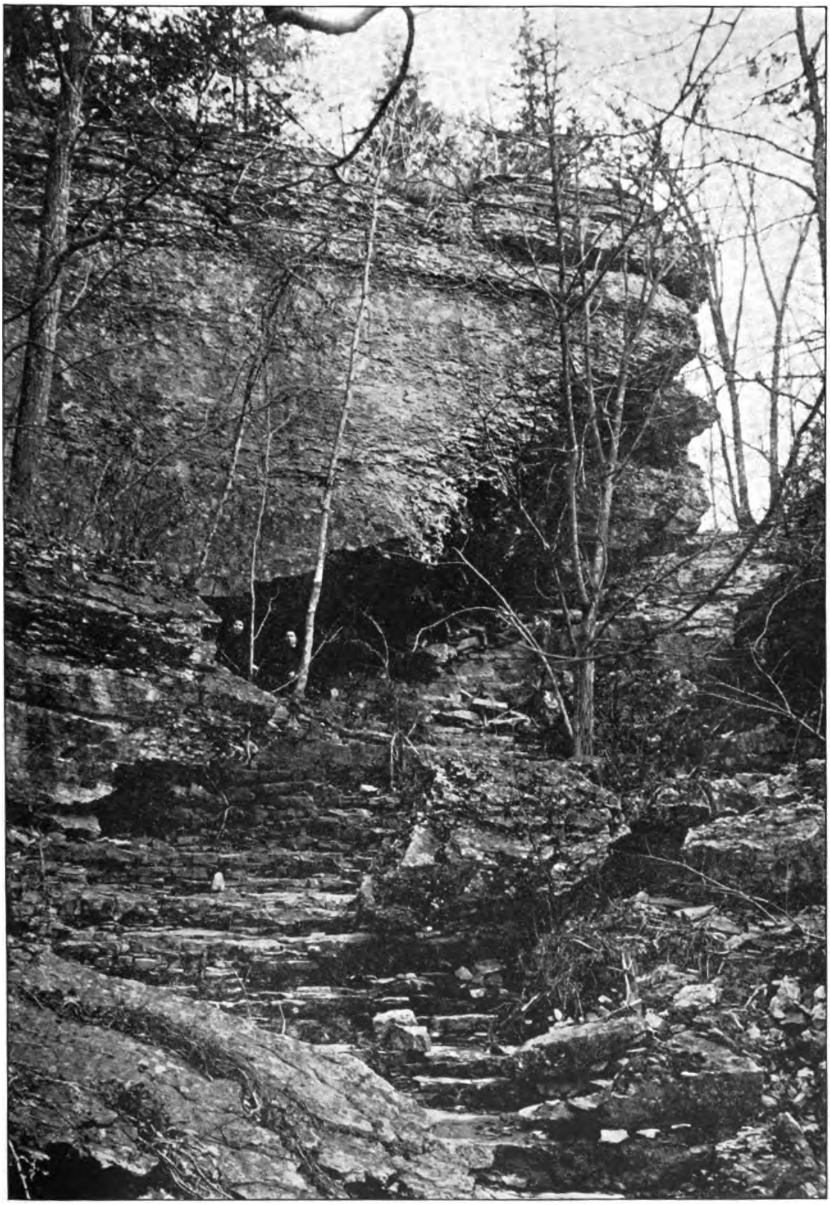
[1] Prosser & Rowe. Stratigraphy of the Eastern Helderbergs. N. Y. State Geol. 17th An. Rep't, p.338. *See also* Schuchert. Am. Geol. 21:173.

thickness of the Rondout waterlime is 4 feet 6 inches. It rests directly and unconformably on the Lorraine shales and is followed conformably by normal Manlius with typical fossils.

From the foregoing it becomes apparent that there was a continuous northward and eastward transgression of the interior or Mississippian sea from the beginning to the end of Siluric time. The origin of the lime mudrocks forming the waterlimes and the Manlius limestone needs a brief consideration. They have been considered as chemical precipitates, but all the characteristics of the rock are against such an assumption and point rather to a clastic origin. Considering this origin as the most likely, the lime mud must have resulted either from the grinding up of organic deposits, such as shell heaps or coral reefs, or through the mechanical erosion of earlier limestones. So far the direct derivation of the lime mud from organic deposits has little evidence to support it. It is true that there may still exist coral reefs or shell heaps of this period which have not yet been exposed by erosion, and that others may have been entirely worn away. Yet in view of the fact that these deposits are uniform over such wide areas and that no remains have been found in them from which such lime flour could be derived, we are hardly justified in entertaining this supposition. If on the other hand we consider that these lime mudrocks were largely formed from the lime mud derived from the Trenton and older limestones, we must postulate that these limestones, which undoubtedly reached far up on the crystalline old land,[1] were covered by Utica and Lorraine sediments at the end of Lorraine time; that these silicious sediments were gradually eroded during early Siluric time, and that at the beginning of the waterlime

[1] The Trenton limestones may actually have covered the Adirondacks, but Kemp is inclined to believe that this was not the case. Cushing, in a recent paper [N. Y. State Mus. Bul. 77. 1905. p.52 *et seq.*] concludes that there was a progressive overlap of the early limestones on the crystallines, capped by Utica shale which may have extended to or above the summit of the entire massive. Wilson cites several cases where Black river corals grew on the crystallines in the neighborhood of Kingston Ont.

Plate 10



Rock shelter, Coeymans limestone, South Schoharie. The weathering occurs along the Siluro-Devonic contact mainly in the transition beds

deposition the shore was abruptly advanced over the eroded sandstone ledges which formed the shore and supplied detrital material, to the newly uncovered limestone ledges [*see* fig. 31 A–B].

That there probably was a sudden deepening of the water and a consequent sudden advance of the shore seems to be indicated by the abrupt change from quartz sandrock to lime mudrock which we see in the sections of the cement region southeast from

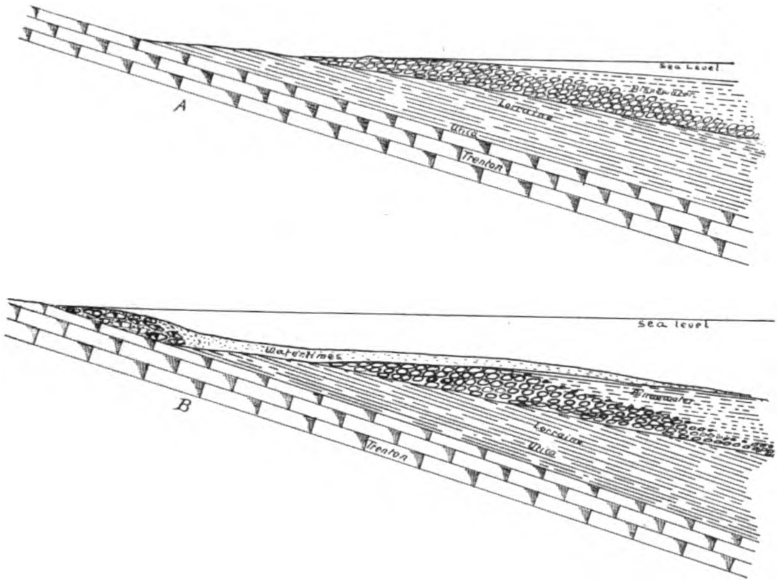


Fig. 31 A–B Diagrams explaining the sudden change from coarse silicious to fine calcareous sediment owing to sudden advance of the sea

Schoharie. That there was an interval of elevation into dry land, accompanied by erosion, between the deposition of the Binnewater sandstones and that of the Rosendale cement bed, can not be held, on account of the total absence of erosion of the sandstones in any of the sections exposed. The bed preceding the cement is uniformly the same in all sections, but has the aspect of having been partially consolidated before the waterlimes were deposited. Irregularities in the thickness of the cement bed are due to irregularities in this floor bed, these irregularities being

structural and not erosional. At Binnewater such an unconformity of deposition without erosion is seen near the old cement tunnels. The following diagram illustrates it [fig. 32].

In the Schoharie region this change brought with it the deposition of the Brayman shales, indicating that the source from which the Schoharie region was supplied was still in large part a silicious shore; the ledges of Lorraine had apparently not been wholly covered by water to the north of Schoharie. Eventually however the shore advanced to the limestone region, which may have been where now is the Mohawk valley, 25 miles or more north of Schoharie. This great distance of the shore explains the fineness of the material, which was carried out to this region, and the scarcity of organic remains which are chiefly restricted to pelagic animals, some of which during later Manlius time accumulated in such abundance as to form the greater part of the limestones. When at any time the conditions became favorable, corals began to grow, and their destruction helped to form the lime sandrocks found at intervals in these Siluric beds.

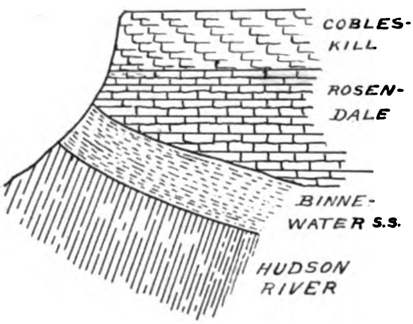


Fig. 32 Irregularities in deposition of Rosendale cement

The shore equivalents of the waterlimes and the Manlius were most probably lime sandrocks and lime rubblerocks which have long since been removed by the extensive erosion to which this region was subjected in Postpaleozoic time, as discussed in chapter 8. The basal irregularity of these deposits, i. e. the thinning out in some places of basal members, is due to irregularities of the old ocean floor, composed of the already consolidated and in places strongly folded and eroded Hudson slates and sandstones.

The sudden transition from Hudson sandstones to limestones of Upper Siluric age, has been frequently noticed by writers. The absence of clastic silicious material at the base of the limestones has been particularly commented on. Van Ingen and Clark record the presence of boulders of sandstone in the "Coralline"[1] limestone near the contact with the upturned and strongly eroded Hudson river sandstones at Rondout, but these boulders are overgrown with Bryozoa and corals, showing that they did not form a part of an actively eroded shore. Had the shore gradually advanced landward, there must of necessity have been formed a deposit of silicious clastics, derived from the underlying beds. In certain cases such an accumulation of clastic material actually occurred as shown by the basal beds at New Salem. As a rule however such beds are absent, indicating a sudden deepening, so that offshore deposits could accumulate on the silicious basement.

This sudden advance of the seashore seems to have produced a breach in the barrier which separated the Atlantic waters from those of the interior continental or Mississippian sea. Through this breach the Atlantic fauna found an entrance, so that in the deposit of this time we have a mingled Atlantic and Mississippi sea fauna.[2]

The fauna of the Cobleskill of Schoharie seems to be a composite of the fauna of the lower Manlius of the interior (Greenfield limestone fauna) and that of the Atlantic province of Siluric time. We know from the Siluric deposits in the Atlantic province that species which in the interior were confined to the Niagaran beds continued in the open ocean practically throughout the Siluric. With the invasion of the Atlantic waters, we would expect these species to make their way into the interior basin again but to

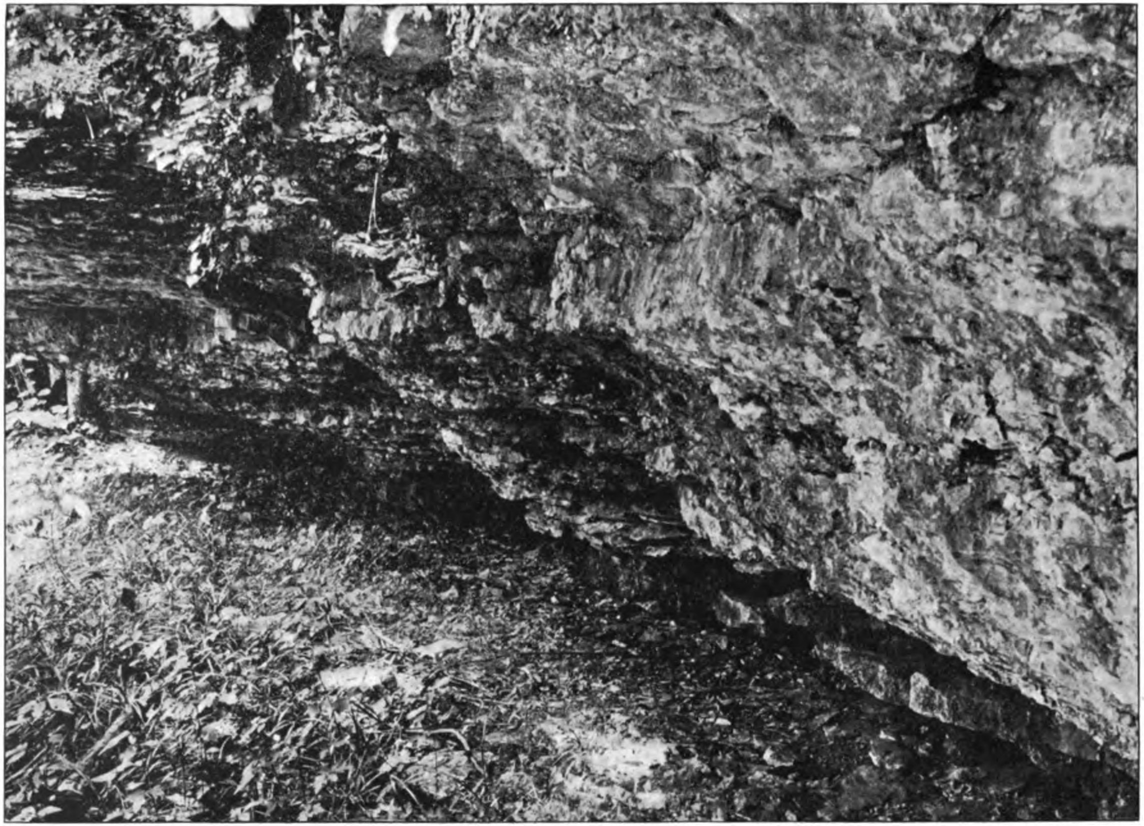
[1] The Coralline limestone of Rondout has been correlated by Hartnagel with the Wilbur limestone, a name applied by him to the basal bed of lime sandrock found in many places between the Rosendale cement, and the Binnewater sandstone. There is some reason to believe however that this Rondout Coralline is the Cobleskill, which here rests directly on a knob of Hudson, around which the Rosendale beds were deposited. [*See* p. 312]

[2] See Hartnagel. *loc. cit.* p.1155.

be more abundant in the eastern deposits of the region than in the western where the species from the interior would hold sway. Halysites catenulatus is one of these species, which is extremely characteristic of the Cobleskill of the Rosendale cement region, but Hartnagel records it from only one locality in the Schoharie region, i. e. northeast of Howes Cave. Again some of the characteristic western species, such as Spirifer eriensis, S. corallinensis, Trochoceras gebhardi and Leperditia scalaris, while common in the Schoharie region, are absent in the Cobleskill of the Hudson valley. S. corallinensis and S. eriensis occur however in the uppermost Manlius of Becraft mountain,[1] showing that by the end of Manlius time these species had made their way east to the Hudson valley.

[1] Grabau. Stratigraphy of Becraft Mountain. N. Y. State Paleontol. An. Rep't for 1902; N. Y. State Mus. Bul. 69, p. 1042

Plate 11



Rock shelter, Coeymans limestone above Clark's cave

Chapter 3

STRATIGRAPHY OF THE SCHOHARIE REGION (continued)

The Lower Devonic rocks of the region

The Schoharie region has long been famous for the clear differentiation and normal succession of the rocks of the Helderberg series and their immediate successors up to the base of the Onondaga limestone. The rocks now classed as Helderbergian [*see* table] were formerly included in the upper part of the Siluric, under the name of Lower Helderberg group.[1] The Tentaculite or Manlius limestone was included in the Lower Helderberg group, for it was generally held that sharp division lines are necessary to separate formations. It is only within the last few years that the Devonic age of the higher portions of the Lower Helderberg group has been established, chiefly by the paleontologic labors of Clarke and Schuchert, and that the dividing line between Upper Siluric and Lower Devonic was definitely established at the top of the Manlius limestone. Till recently the formations under consideration have been known by the names given them by the early geologists, among whom John Gebhard esq. and Lieut. W. W. Mather were specially concerned with the Helderberg rocks. Paleontologic names were largely selected for the formations by these geologists, but these have since been replaced by names selected from typical localities, mostly in the Hudson valley. The following table shows the Lower Devonic formations with the present and former names, the highest beds being placed at the top of the table and the current nomenclature at the left.

[1] The Upper Helderberg group included the Esopus and Schoharie grits and the Onondaga limestone.

Oriskanian	Esopus grit	Cauda-galli grit	
	Oriskany formation	Oriskany sandstone	
Helderbergian	Port Ewen limestone	Upper shaly limestone (in part)	Lower Helderberg group
	Becraft limestone	Upper Pentamerus, including Scutella and Encrinal limestones	
	New Scotland shaly limestone	Catskill shaly or Delthyris shaly limestone	
	Coeymans limestone	Lower Pentamerus or Pentamerus limestone	
Upper Siluric	Manlius limestone	Tentaculite limestone	

The Coeymans or Lower Pentamerus limestone

This formation has a thickness of about 50 feet in this region. It is mainly a rather coarse semicrystalline limestone composed of fragments of shells, crinoids and corals. At intervals the rock is a nearly typical shell limestone or coquina, with the brachiopod shells composing it largely in a perfect state of preservation. These weather out in relief on the exposed edges of the rock and with care may be collected from these surfaces. Even when perfect shells are abundant, the main mass of the rock is nevertheless formed of fragments, and this fact renders the rock a very compact, hard limestone of very uniform grain, and generally of a dark color, the color being due not so much to impurities as to the manner in which light is reflected from the innumerable cleavage surfaces of the small calcite grains.

No coral reef structure has been observed in this rock in any of its exposures, though heads of corals, specially *Favosites helderbergiae* are often quite common, more particularly in the lower part of the formation. These corals often appear to be in the place where they grew, in which case they are represented by perfect heads. Not infrequently however coral fragments alone are present or are mingled with the unbroken heads. In such cases even the perfect heads are found overturned, while the fragments lie in all positions.

The lower beds of the Coeymans formation are generally massive limestones, while the upper ones are more thin bedded and generally show a transition to the overlying New Scotland formation. This relative character is maintained throughout the Helderberg region, and is also found in the outliers east of the Hudson, Mt Becraft and Mt Bob. Topographically this is expressed by a cliff wherever the massive beds are exposed and by a slope above this, formed by the thinner bedded strata. The cliff of the lower Coeymans is conspicuous everywhere in this region, being particularly prominent on both sides of West mountain and on the south face of Barton hill along the Fox kill. The cliff not infrequently overhangs owing to the recession, by weathering, of the transition layers between it and the Manlius. Thus there is generally a cavernous recession at the base of the Coeymans, which in many places forms an adequate rock shelter [*see* pl. 11]. It is at the base of this rock that the remarkable crinoid Melocrinus pachydactylus [fig. 33] has been found, the locality furnishing most of the specimens obtained, being the cliff east of Schoharie courthouse. The thickness of the formation at Rondout, New Salem and at Indian Ladder is the same as at Schoharie, i. e. 50 feet, while at Mt Becraft its thickness is 45 feet. There is generally much chert in the upper portion of this formation, but this appears to be wanting entirely in the exposures of the Schoharie region. At Howes Cave the

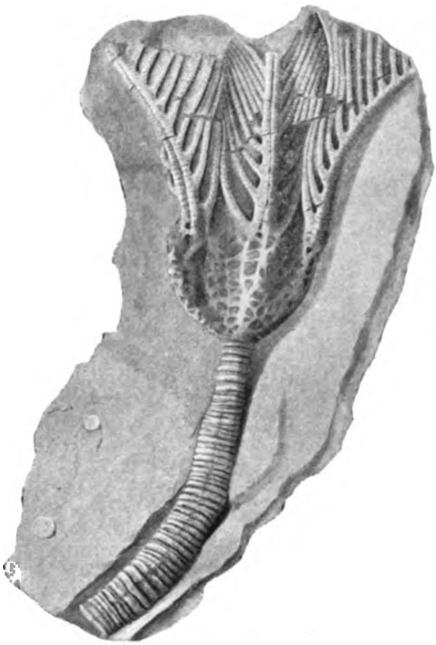


Fig. 33 Melocrinus pachydactylus

lower portion is quarried together with the Manlius and manufactured into Portland cement. In composition it is similar to the Manlius, though in texture it is always a sandrock.

The most accessible exposure of the Coeymans in the Schoharie region, is in "the rocks" which extend in a cliff from behind the cemetery at Schoharie southward till they cross the Middleburg road about a mile south of Schoharie courthouse. The rock has been quarried at two places for road metal, one in the cliff back of Schoharie courthouse, and the other at the northern end of Lasell park. Though the formation is well exposed on West hill, only the upper layers can be examined, as the lower 25 to 30 feet forms an almost inaccessible perpendicular or overhanging cliff. On the road leading up West hill, however, a short distance beyond the point where it branches off from the East Cobleskill road, a good section of the formation is found. The lowest beds exposed in the cliff along the roadside are the upper Manlius beds, of which about 33 feet are shown. These are succeeded by about 32 feet of massive Coeymans, part of which is quarried by the roadside. Above this are about 20 feet more, forming low ledges in the field, and then follows a slope of New Scotland [*see* section fig. 198]. Southward good outcrops are found behind the Gebhard farm in cliffs below the road [map: IX h, 46]. Good cliffs of lower Coeymans, rich in fossils, are also found south of the Cobleskill, between Braymanville and the Howes Cave road [map: VI f, 32] and again halfway between Braymanville and Barnerville [map: V b, 30] where ledges of Coeymans traversed by wide master joints, project into the Cobleskill for some distance. At Barnerville, ledges of Coeymans with fossils are well exposed in the village and on the south banks of the stream. On Barton hill good exposures of the Coeymans are found in low cliffs which almost encircle the hill.

Fossils of the Coeymans

The following are some of the more characteristic species.

Crinoids. Melocrinus pachydactylus [fig. 33]. This large and beautiful species was found in the shaly layers

at the base of the Coeymans in the cliffs in the eastern part of the village. It is one of the first crinoids found in this region, and one of the most beautiful. Lepadocrinus gebhardi [fig. 34] is also abundant in this formation, the tapering stems being frequently found. The nutlike head, composed of irregular plates, is easily recognized. The species belongs to the group of the Cystoids.

Fig. 34 Lepadocrinus gebhardi

Among the brachiopods, Stropheodonta varistriata [fig. 35] is the most abundant and characteristic of the lower beds. It is frequently larger than in the Manlius. Other characteristic brachiopods are: Camarotoechia semiplicata [fig. 36], a small species, smooth in the upper portions and with a few small plications near the base; very abundant in some of the layers and represented by a variety [*see* fig. 27 a-h] in the transition beds at the top of the Manlius; Uncinulus mutabilis [fig. 37], a robust, rounded form with numerous rather faint and rounded plications, and pronounced anterior emargination, often occurs in considerable abundance; Atrypa reticularis [fig. 38], generally robust and easily recognized by the unequal convexity of the valves and the reticulated surface markings, and Sieberella galeata [fig. 39], easily recognized by its form, the strong overarching beak of the pedicle valve and the strong rounded

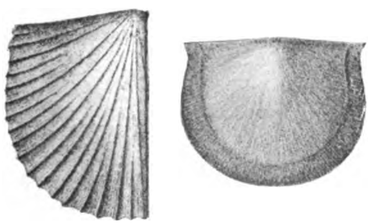


Fig. 35 Stropheodonta varistriata

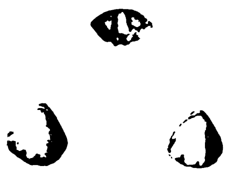


Fig. 36 Camarotoechia semiplicata

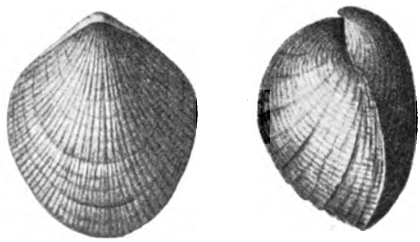


Fig. 38 Atrypa reticularis

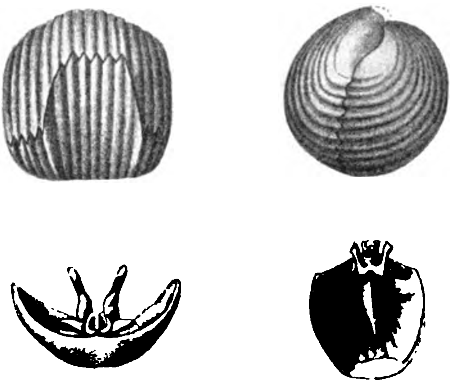


Fig. 37 Uncinulus mutabilis

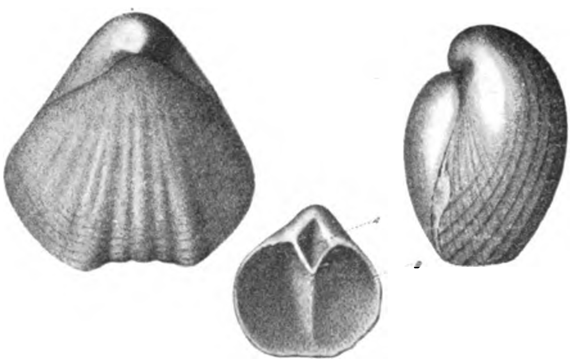


Fig. 39 Sieberella galeata

plications which however may become faint or even wanting in some individuals, which then resemble S. pseudogaleata [fig. 74].

Besides the species mentioned, which may be regarded as the diagnostic fossils of this formation, there are a number of other brachiopods, as well as trilobites, which, however, are also found in the New Scotland. These are all listed in chapter 7.

New Scotland beds

Delthyris shaly limestone; Catskill shaly limestone;
Lower shaly limestone; of various authors

This formation, which immediately succeeds the Coeymans limestone, is not so well exposed in the Schoharie region as it is in other parts of the Helderberg escarpment. This is due to the fact that the rock weathers readily, and hence forms soil-covered slopes, which are commonly utilized for grazing purposes, being in most cases too steep for profitable tilling. Hop and grain fields are however by no means uncommon on this rock when its outcrops form gentle slopes. More continuous and satisfactory outcrops of this formation are found in New Scotland township in Albany county which has given the name to the formation, and at Becraft mountain in Columbia county and Rondout in Ulster county.

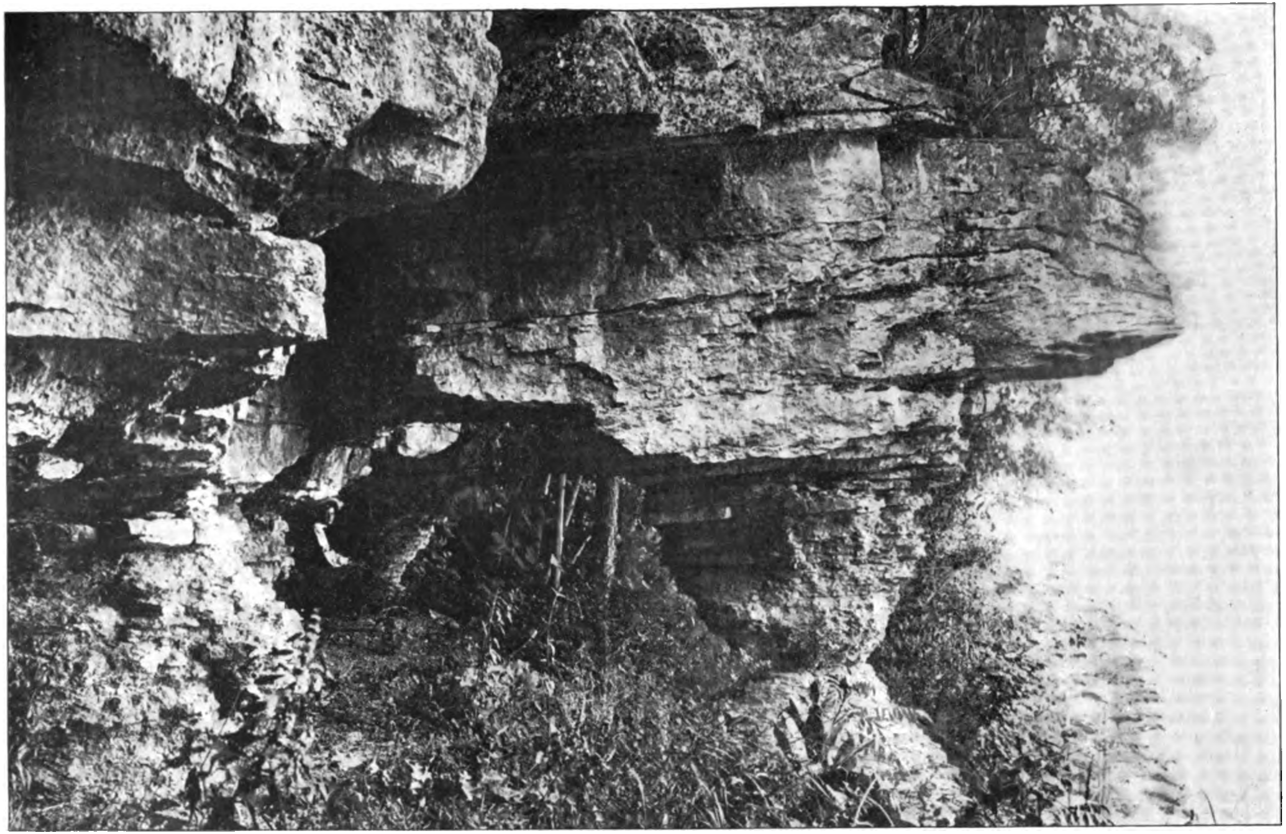
In the Schoharie region as in most places along the Helderberg escarpment the Coeymans limestone grades upward into the New Scotland beds and it becomes difficult to draw the line between the two formations. The upper Coeymans beds gradually become more thin bedded, and impure layers containing much argillaceous and silicious material make their appearance. These gradually increase in proportion till there remains but a comparatively small portion of the limestone. At intervals hard calcerous beds appear which generally crop out on the hill slopes, but for the most part the rock seems to disintegrate readily and form clays. These disintegrated masses may often be seen along the roadsides and form interesting sources for the collection of weathered-out fossils. The more resistant

layers generally break up into blocks or slabs of moderate size and are commonly found resting on the surface of the slope underlain by this rock. These fragments generally have their surface covered with weathered-out fossils, chiefly brachiopods and bryozoans, and in the majority of localities in the Schoharie region they form the only available source of the fossils of this rock.

Very often these fragments are used in the construction of stone fences where however they are associated with other rock masses from higher or lower strata. One of the best places for the collection of the fossils of the upper portion of this rock is along the line of contact with the overlying Becraft limestones. There is generally some weathering back along this contact, the more massive Becraft limestone overhanging and sometimes forming rock shelters. Behind the house of Mr Sam Clark, on Dann's hill opposite Schoharie, one of these rock shelters has been formed, the projecting ledge being supported by a pillar of New Scotland [*see* pl. 12]. Near by is a small cavern worn along the Becraft-New Scotland contact line by a small stream which runs dry during the summer months. In the floor and arch of the shelter many weathered-out specimens of well preserved fossils may be obtained. At this point the slope underlain by the New Scotland beds is very steep, and numerous broken fragments of the harder beds of this series, together with slabs of the lower Becraft, formerly covered the surface, but have been gathered and piled up in fences behind which the soil of the slope is retained. From these fragments many good fossils may be obtained.

Farther north, on the slope of West or Terrace mountain, below the house of Mr George Acker, other good opportunities for collecting fossils from this horizon are offered. In fact, with the exception of a few outcrops on East hill above Schoharie, specially near the Mix and O'Reilly quarries, the best opportunity for the collection of the fossils from this formation is in West and Dann's hills, between the Coeymans cliff below and the Becraft cliff above. The nearest good collecting ground for these fossils in the Helderberg is on the slopes of High Point;

Plate 12



Arch formed of Becraft limestone supported by a pillar of upper New Scotland. Dann's hill behind the house of Sam Clark

above the Coeymans cliff about a mile south of Altamont, while other good exposures are found at Indian Ladder, New Salem, Becraft mountain and on North hill near Kingston.

The thickness of the New Scotland beds in the Schoharie region averages 115 feet. At New Salem it is 120 feet thick; near Clarksville, 127 feet. At Becraft mountain from 70–75 feet occur while at Kingston the thickness is estimated at 100 feet.

Fossils of the New Scotland beds

As will be seen from the list of fossils in chapter 7, this formation is one of the richest of the Helderberg series. Only a few of the most typical species can be mentioned.

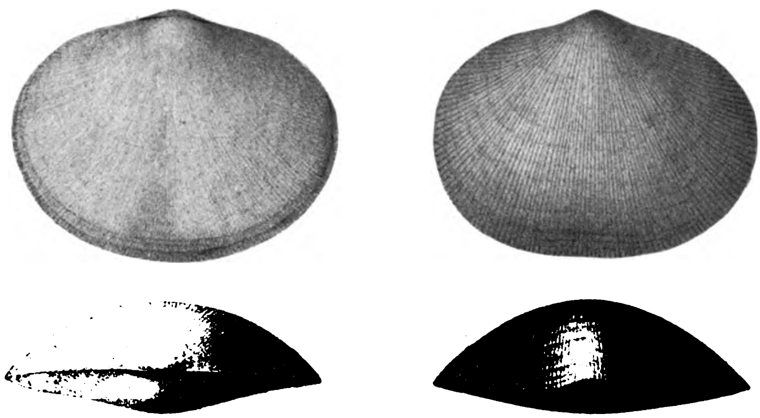


Fig. 40 Rhipidomella oblata

Brachiopods. Rhipidomella oblata [fig. 40 and 40a.] This species may be recognized by its broadly rounded outline, short hinge area, the greater convexity of the brachial valve and the fine radiating surface striae. It is a common species.

Dalmanella perelegans [fig. 41] and D. subcarinata [fig. 42] are also characteristic species, and can be distinguished from the preceding by the shallower brachial valve, which generally has a depression down the center, while the pedicle valve is strongly convex. Of the two species the first has a more sloping hinge area and a more strongly convex brachial valve.

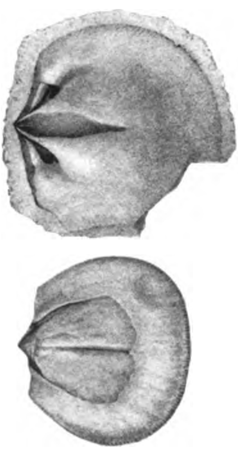


Fig. 40a Rhipidomella oblata; internal molds

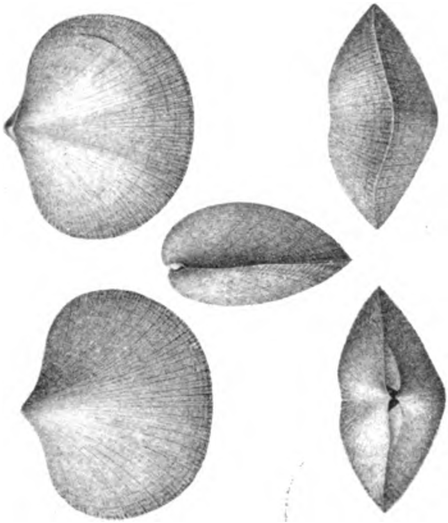


Fig. 41 Dalmanella perelegans

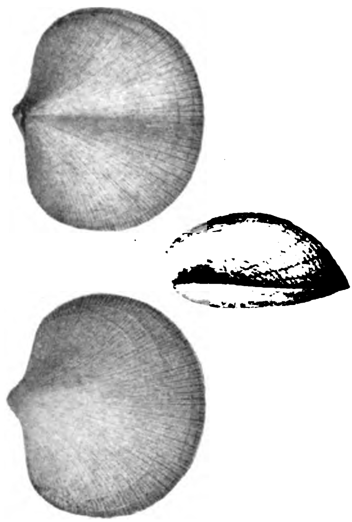


Fig. 42 Dalmanella subcarinata

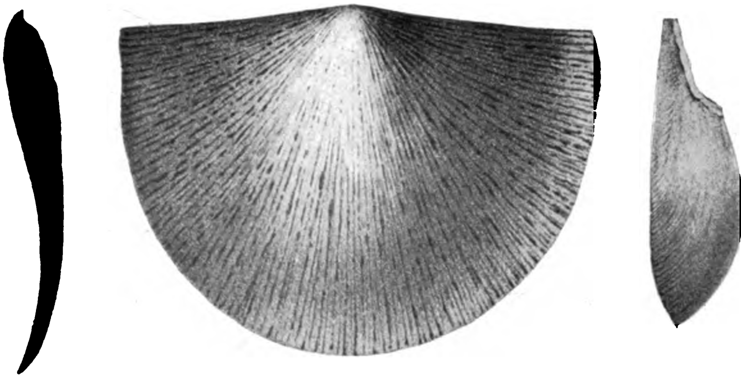


Fig. 43 Strophonella headleyana

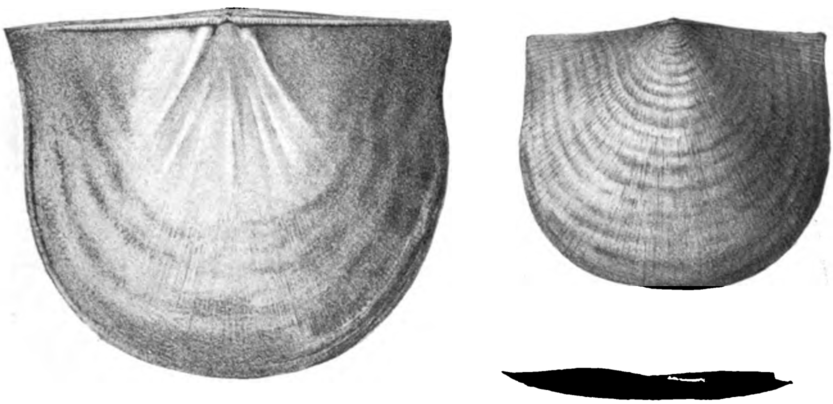


Fig. 44 Leptostrophia becki

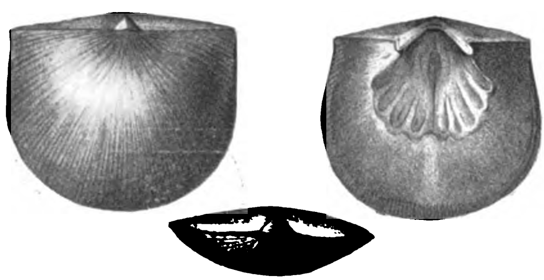


Fig. 45 Orthothetes woolworthanus

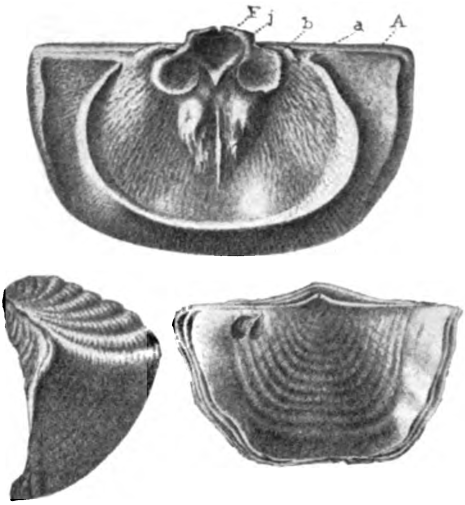


Fig. 46 Leptaena rhomboidalis

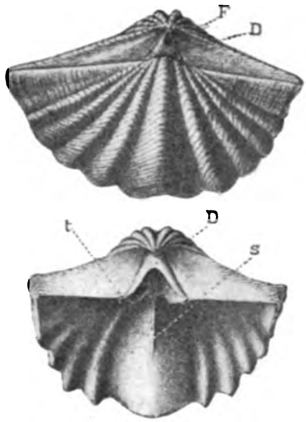


Fig. 47 Spirifer perlamellosa

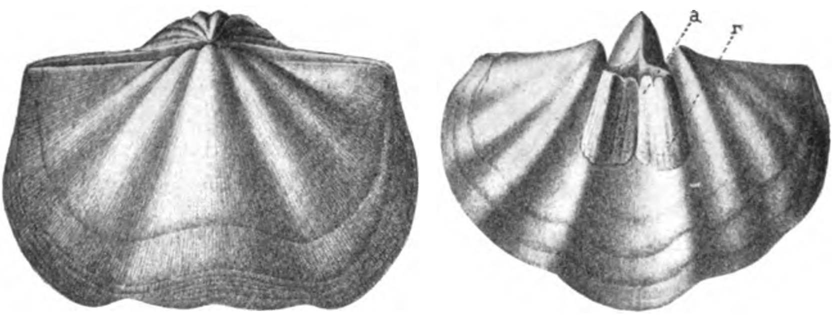


Fig. 48 Spirifer macropleura

Fig. 49 Uncinulus nucleolatus

Strophonella headleyana [fig. 43], Leptostrophia becki [fig. 44] and Orthothetes woolworthanus [fig. 45] are the most characteristic strophomenoid shells. Of these the first two are characterized by a crenulated hinge line, the first having the convexity of the valves reversed while L. becki is normal, often almost flat, and not infrequently with concentric wrinkles; the spreading muscular impressions are also very characteristic. O. woolworthanus likewise has the convexity of the valves reversed, but has a broader hinge area than S. headleyana and no crenulations.

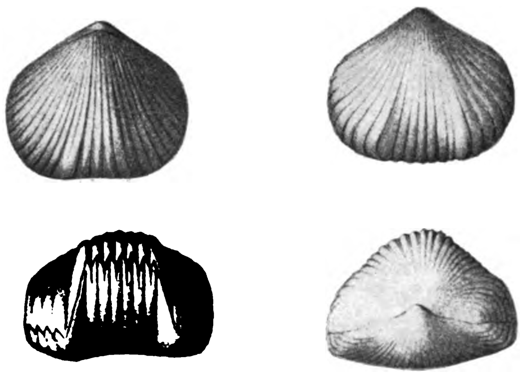


Fig. 50 Uncinulus abruptus

Leptaena rhomboidalis [fig. 46] one of the commonest brachiopods of this horizon, is easily recognized by the strong concentric wrinkles and the abrupt anterior deflection.

Among the Spirifers S. perlamellosus [fig. 47] is readily recognized by its rounded plications and strong lamellose concentric striae; while S. macropleura [fig. 48], the most characteristic species of this horizon, may be known by its large size, few, very broad and gently rounded plications and numerous fine radiating striae.

Among the rhynchonelloid shells Uncinulus nucleolatus [fig. 49] U. abruptus [fig. 50] and U. vellicatus [fig. 51] occur, all of which are robust and readily distinguished by the characters shown in the illustrations.

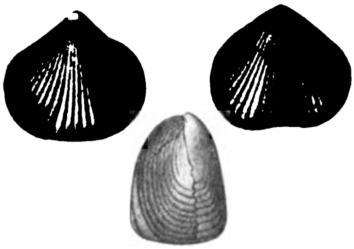


Fig. 51 Uncinulus vellicatus

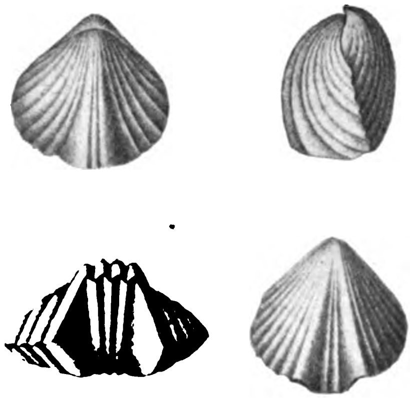


Fig. 53 Stenoschisma formosum

Fig. 52 Stenoschisma altiplicatum

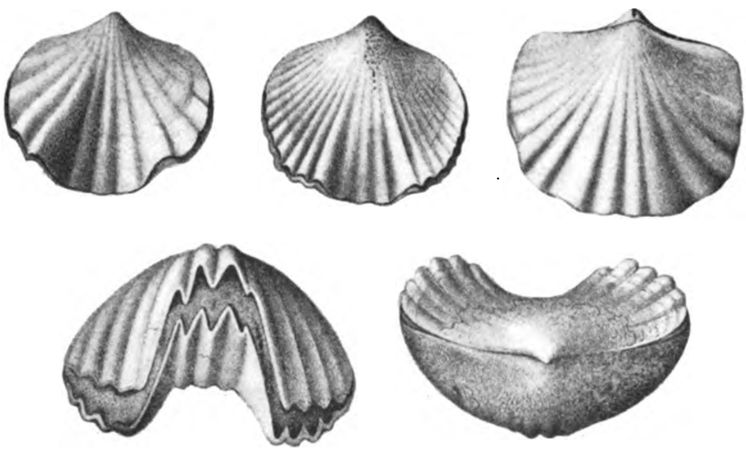


Fig. 54 Eatonia medialis

Stenoschisma altiplicatum [fig. 52] is readily distinguished by the abrupt anterior emargination due to the deep folding sinus. It is, however, not so readily distinguished from Stenoschisma formosum [fig. 53], which is a broader and less triangular shell.

Eatonia medialis [fig. 54] is a rhynchonelloid with an abrupt and marked anterior deflection, and rounded plications chiefly at the anterior margin.

Among the smooth brachiopods are Meristella laevis [fig. 55], M. arcuata [fig. 56 and 56*a*] and M. princeps

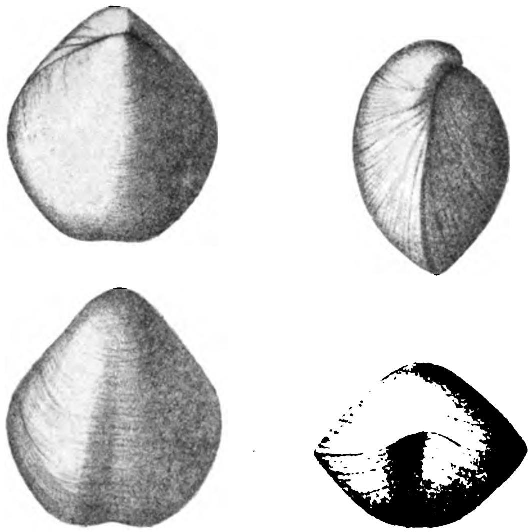


Fig. 55 Meristella laevis

[fig. 57], which are readily distinguished from one another by their form and proportion and from the other brachiopods of this horizon by the absence of surface striae or plications.

Atrypa reticularis [fig. 38] is abundant in this as in the other formations.

A number of pelecypods occur in this horizon, but on the whole they are not common or well preserved. One of the most readily recognized is Actinopteria textilis [fig. 58], which is very oblique, with a strong posterior wing, and sharp radiating striae cancellated by concentric lines. A. securi-

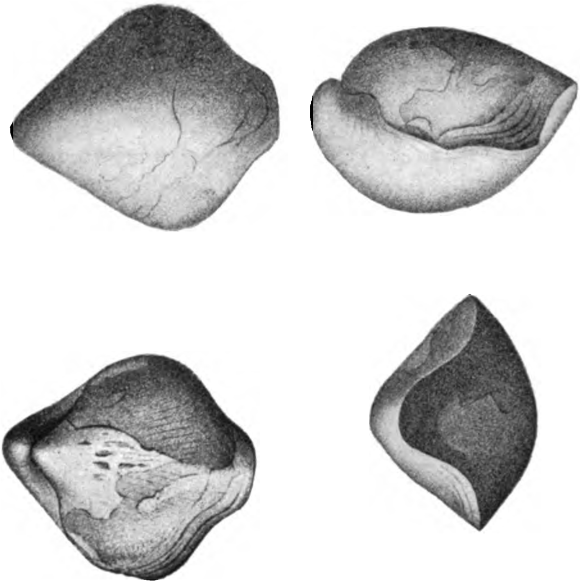


Fig. 57 Meristella princeps

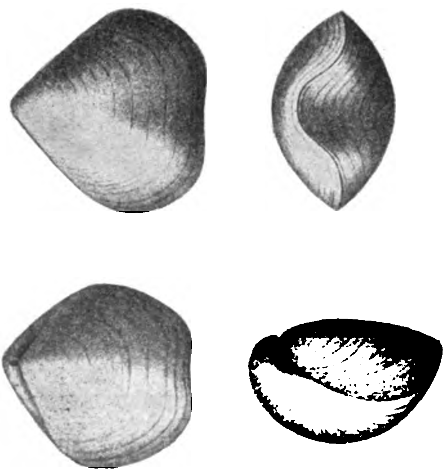


Fig. 56 Meristella arcuata

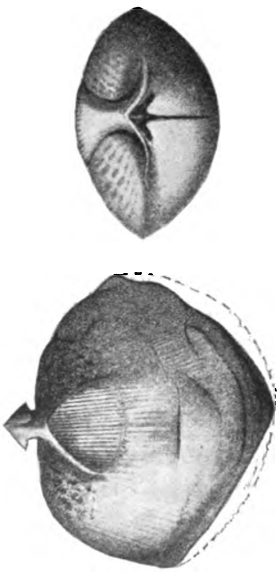


Fig. 56a Meristella arcuata; internal molds

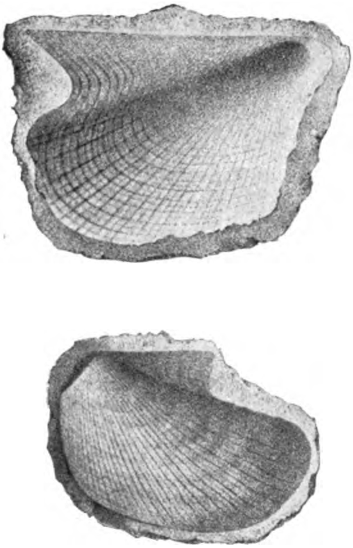


Fig. 58 Actinopteria textilis

Fig. 59 Actinopteria securiformis

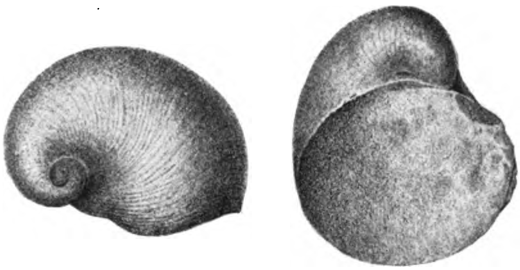


Fig. 60 Platyceras ventricosum

Fig. 61 Platyceras gebhard

Fig. 62 Platyceras multisinuatum

Fig. 63 Platyceras spirale

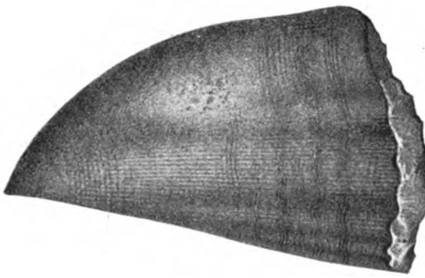


Fig. 64 Platyceras plicatum

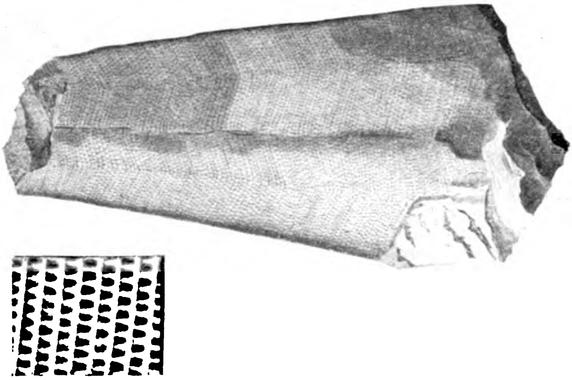


Fig. 65 Conularia huntiana

formis [fig. 59], a less oblique species, is also common in this and other horizons.

The gastropods are well represented by the type Platyceras which is represented by species showing various degrees of non-coiling. P. ventricosum [fig. 60] and P. gebhardi [fig. 61] are the most closely coiled and easily distinguished from each other by the ventricosity of the first species. A few of the

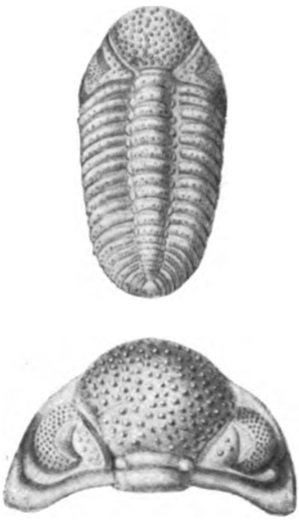


Fig. 66 Phacops logani

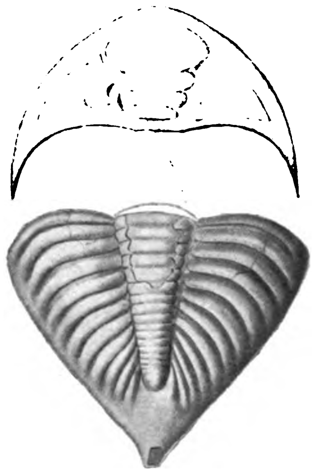


Fig. 67 Dalmanites pleuroptyx

more characteristic species with slight coiling are represented in the illustrations [figs. 62–64] and they give an idea of the instability of the form of this very variable gastropod.

Various species of Orthoceras occur in this and in the preceding horizon. They are generally poorly preserved. O. helderbergiae may be given as an example.

Among the pteropodous mollusca, Conularia huntiana [fig. 65] may be cited. The species is easily recognized by its form and peculiar surface markings.

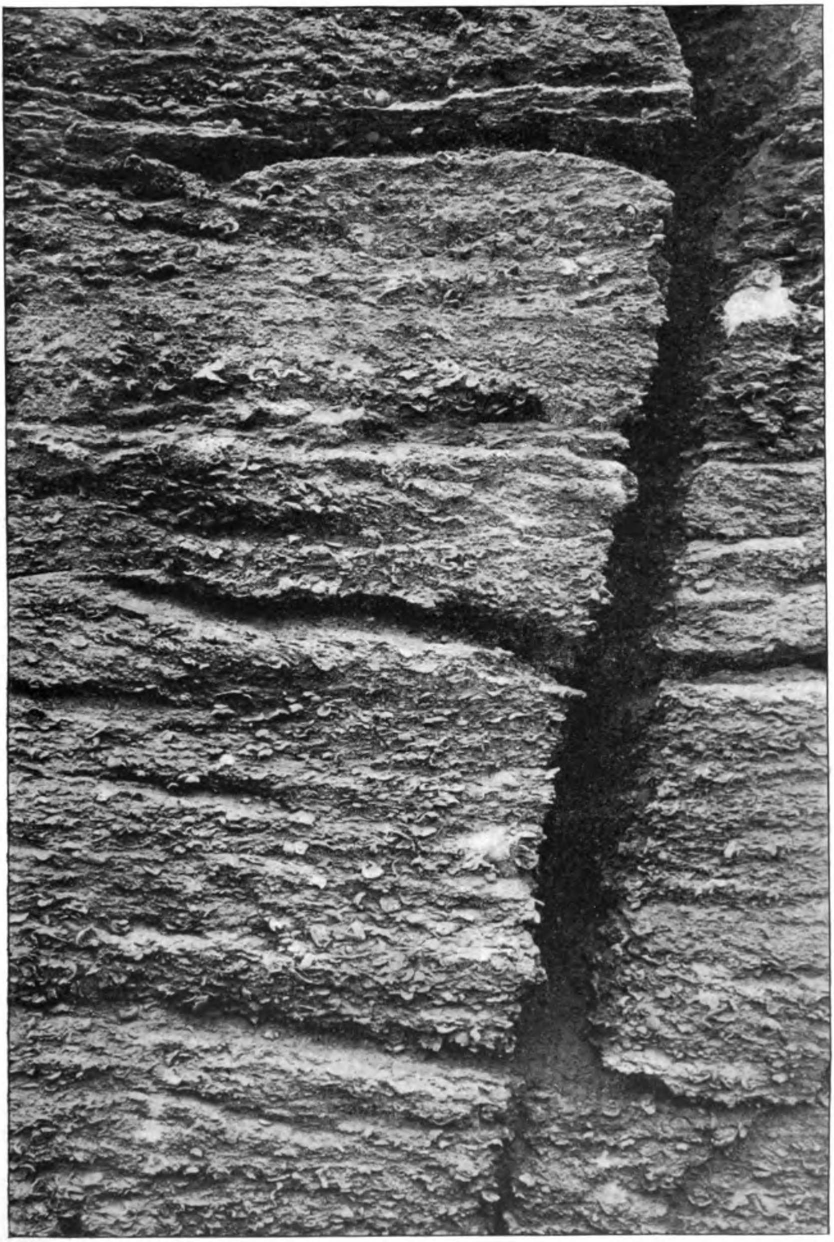
Trilobites are not uncommon in this formation, but perfect specimens are not easily obtained. Phacops logani [fig. 66] is one of the most abundant and readily recognized by its strong

and pustulose glabella, the position of the eyes and the general outline of the body as shown in the illustration. Dalmanites pleuroptyx [fig. 67] is characterized by a deeply lobed glabella, which widens rapidly toward the front; by the strongly

Fig. 68 Dalmanites nasutus

crescentic outline of the head, with the moderate lateral spines, and by the large triangular pygidium. Another species, D. nasutus [fig. 68], is characterized by a bifurcating anterior extension of the head, longer and sharper genal spines, and a pygidium furnished with a long, narrow spine or telson.

Plate 13



Becraft limestone showing weathered surfaces with shells and crinoid fragments in relief. Quarry on East hill above Schoharie [*see* pl 14]

Becraft limestone

Scutella and Encrinal limestones [Vanuxem etc.], Sparry limestone [Gebhard], Upper Pentamerus limestone, Upper member of the Delthyris shaly limestone [Mather], Upper limestone of Becraft mountain

This limestone was included by Mather in his Delthyris shaly series, but has always been treated by subsequent authors as a separate formation. Its best exposure is on Becraft mountain near Hudson, where it is 45 feet thick and extensively quarried at the present time and manufactured into Portland cement.

Lithically the rock is a coarse-grained crystalline lime sandrock, densely packed with brachiopod shells, so that not infrequently it has the character of a shell rock or coquina. This character is well shown on the weathered edges of the rock, where the shells stand out in relief, as shown in the photographs [pl. 13, 14]. The rock is massive bedded, compact and hard, and when fresh of a dark gray color, but weathering creamy or white. The lower part is rich in joints of crinoid columns, which are also frequent throughout the mass. The basal portion of a large crinoid, Aspidocrinus scutelliformis is common in the lower part. The fancied resemblance of these fossils to the echinoid Scutella has given rise to the term " Scutella limestone ". These calyx bases are from one to two inches in diameter, generally flatly bowl-shaped, though sometimes having more the shape of a very flat cone, with an apical aperture. The whole shield is rendered crystalline by secondary infiltration of calcic carbonate, as is usual in echinoderm remains, and the cleavable calcite masses thus produced are very characteristic and easily recognizable. They form a good index to the formation. On the weathered surfaces these basal shields often stand out in relief and in such cases their true form and character can be well seen. In the lower and middle portions of the rock the shells composing it are mainly Spirifers and rhynchonelloid brachiopods. In the upper portion however Sieberella pseudogaleata [fig. 74], the index fossil of this formation, predominates.

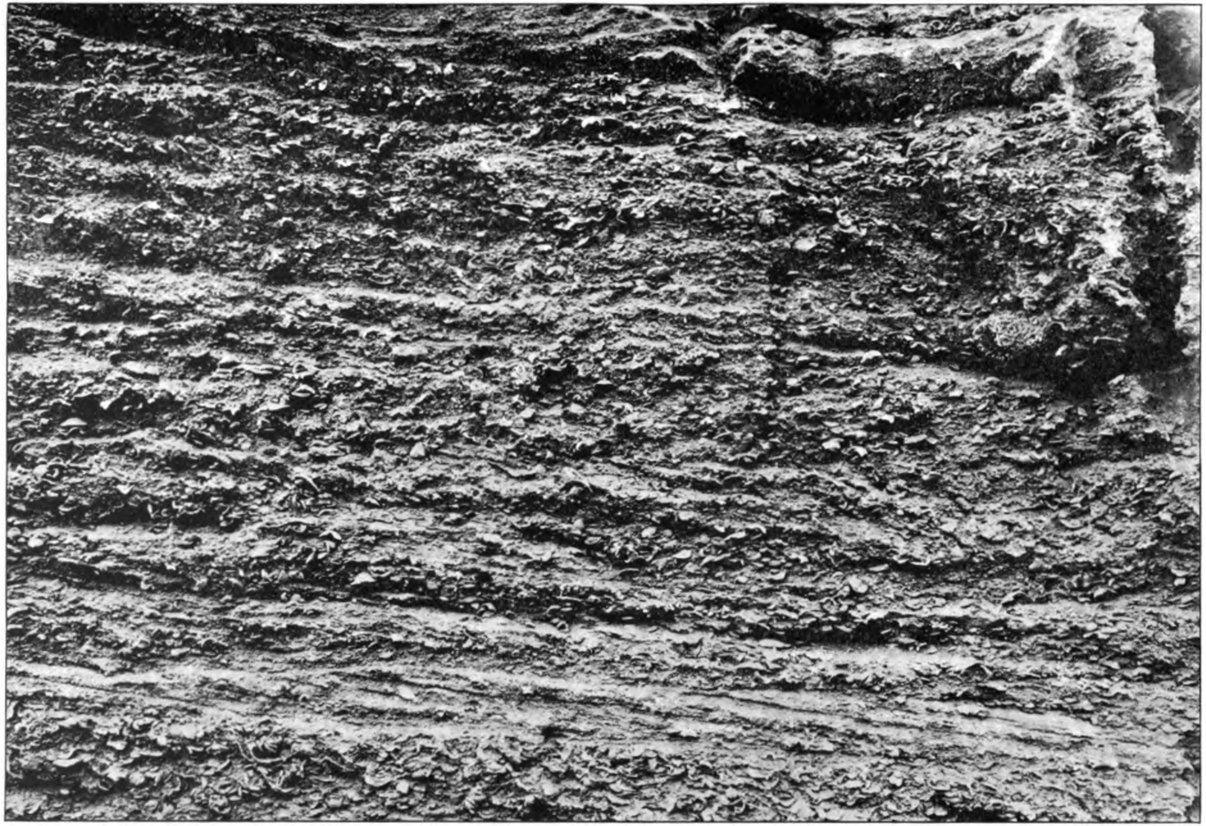
From its resistant character this limestone mostly forms cliffs, which are often very pronounced and generally project above the

New Scotland beds as rock shelters, owing to rapid disintegration of the underlying beds at the contact line [*see* pl. 12]. The heavy beds of rock are traversed by joint cracks, which by solution frequently become widened into fissures of considerable extent.

Exposures are numerous in the Schoharie valley but less frequent and accessible in that of the Cobleskill. On both West and East hills and on Dann's hill good cliffs of this rock extend for miles above the New Scotland slope. One of the best exposures is in front of the home of Mr George Acker on West hill, where a cliff of 15½ feet of the limestone may be seen extending for some distance just below the road. Above this are 5½ feet of similar rock, after which the limestones become somewhat finer grained, darker and more compact, with fewer organic remains. These upper beds with a thickness of 10–15 feet may represent a part of the Port Ewen or Upper Shaly bed series, which is otherwise unrepresented in this vicinity. At any rate they are lithically identical with beds occupying a similar position at Becraft mountain and which there represent the Port Ewen beds.

Including these beds with the Becraft, from which they scarcely differ lithically, we have about 30 feet of strata between the New Scotland and the Oriskany. At Countryman hill near New Salem the Becraft has a thickness of only 17 feet and is at once succeeded by 2 feet of Oriskany. At Clarksville, a mile farther south, it is 20 feet thick and is succeeded by 1 foot of Oriskany. At Becraft mountain, where the thickness of the Becraft is 45 feet, there are from 20 to 25 feet of Port Ewen between it and the Oriskany, the transition being apparently a gradual one. At Rondout on the other hand, where the Becraft has a thickness of about 35 feet, it is succeeded by 110 feet or more of Port Ewen or Upper Shaly beds. The great thickness of the Port Ewen beds here is mainly due to a difference in the material of which it is made, this being in a large measure argillaceous and silicious clastics, whereas at Becraft mountain it is mainly a deposit of lime sandrocks.

Plate 14



Becraft limestone showing weathered surface. East hill above Schoharie

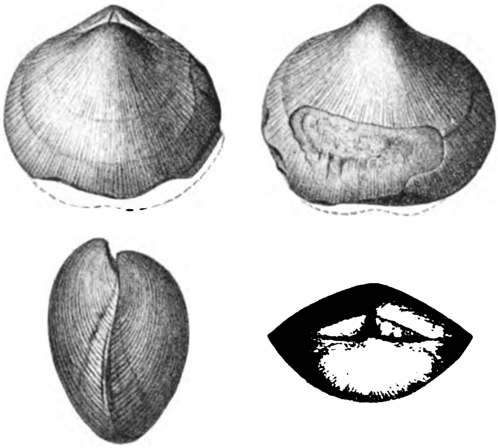
These facts point to an hiatus or stratigraphic unconformity between the Becraft and the Oriskany, which may be due merely to nondeposition in the Schoharie and Helderberg region, without much erosion of previously deposited rocks.

The Becraft, though a very good limestone, is quarried only in two places in the Schoharie valley. One is on the slopes of East hill on the road which leads up the hill northeast from Schoharie [map: XI g, 44], and the other about half a mile east of Frisby's mills in a field between the Middleburg road and the railroad track [map: IX j, 62].

Fossils of the Becraft limestone

While this limestone is almost entirely composed of fossils, the number of species is limited. The crinoids are mainly represented by Aspidocrinus scutelliformis, of which only the broad, shieldlike base is preserved. This is very abundant in the lower Becraft and the upper New Scotland, for which reason this portion of the formation was formerly called the Scutella limestone. This fossil varies from one to two inches in diameter, and in convexity, from low-rounded to subconical. It is always crystallized and the calcite cleavage is a very characteristic feature.

The brachiopods are the most characteristic fossils of this horizon. Among the orthid shells Schizophoria multistriata [fig. 69] with its strongly convex valve, and sharp, fine surface striae, predominates. Spirifer concinnus [fig. 70] is generally represented by small individuals with faint rounded plications and shallow rounded sinus. It is the only common species of the genus. On large specimens the fold of the brachial valve shows incipient plications. The rhynchonelloid shells are represented by Stenoschisma formosum [fig. 53] already noted in the New Scotland; Wilsonia ventricosa [fig. 71], a small round, extremely ventricose species, with low rounded plications; Uncinulus campbellanus [fig. 72] and U. nobilis [fig. 73] easily distinguished by their form and plications. Meristella princeps [fig. 57] and Atrypa reticularis [fig. 38] also occur in this



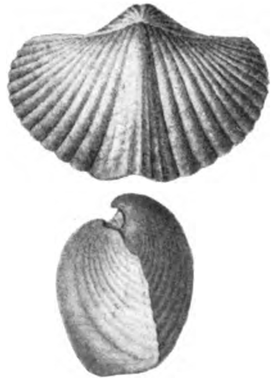


Fig. 70 Spirifer concinnus

Fig. 69 Schizophoria multistriata

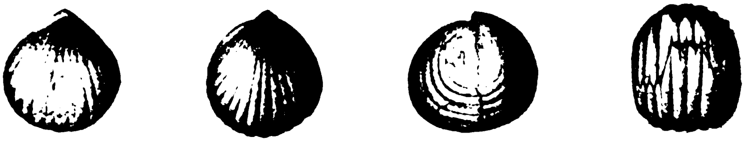


Fig. 71 Wilsonia ventricosa

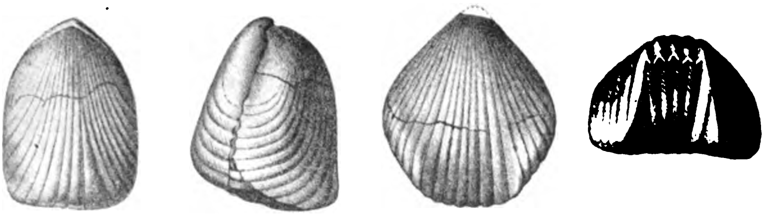


Fig. 72 Uncinulus campbellanus

Fig. 73 Uncinulus nobilis

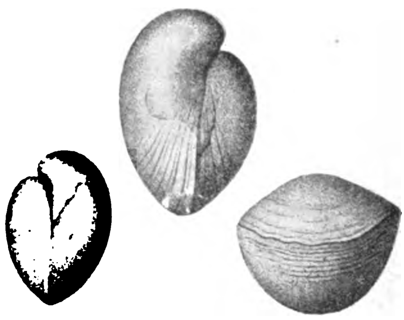


Fig. 74 Sieberella pseudogaleata

horizon. By far the most characteristic and abundant species is Sieberella pseudogaleata [fig. 74], easily distinguished from S. galeata by its more elongated form and absence of plications. As already stated the upper portions of this limestone are sometimes entirely composed of this species. A number of gastropods occur but they are not abundant.

Oriskany formation

Resting on the Becraft limestone or on the darker limestones which in some places succeed the Becraft and represent the Port Ewen beds of the central Hudson region, we find in a great many localities in this district a dark, silicious and very fossiliferous limestone. This is the representative of the Oriskany, which at Oriskany Falls, Oneida co., its type locality, consists of 20 feet of nearly pure, white fossiliferous quartz sandrock. The rock of the Schoharie region appears to be a mixture of quartz and lime sand grains. The latter are commonly dissolved out in the exposed rock, which then changes from a dark bluish gray very compact rock, in which the fossils are distinguishable with difficulty, to a brown porous sandrock with the fossils represented by both external and internal molds, which are beautifully preserved and show every detail of marking characteristic of the original which has been dissolved away. The upper member of the formation is a compact quartzite, which forms an even and level floor, marked only by peculiar wave marks, which resemble in a general way the markings found in the Esopus shale next above, and are known by the name of Spirophyton (Taonurus) cauda-galli. This upper surface of the Oriskany is so marked that it is readily recognized at a glance. It has been noticed throughout the Helderberg region, retaining its marked surface everywhere. From the hardness of this surface layer and the softness of the overlying Esopus shales it follows that erosion is largely concerned with the removal of the overlying soft beds. Thus the Oriskany forms a level platform or terrace wherever the beds are nearly horizontal, a feature which may be observed in a great many places in the Helderberg region. Near Schoharie this may be seen on both West and East hills above the village, the

best localities being at the house of Mr George Acker on West mountain, where a red barn, visible from Schoharie, stands directly on this surface; and on East mountain above the Fox kill, where the road for some distance runs on this stratum.

The two places just mentioned furnish the best localities for collecting the Oriskany fossils of this region. The fossils are best obtained from the loose blocks which are found plentifully scattered about the fields or piled up in fences. The weathered rock is easily shattered by the hammer, and care must be taken to get the fossils without injuring them.

On the eastern side of West hill there appear to be from 5 to 6 feet of the Oriskany, but owing to the imperfect sections exposed, no accurate determinations could be made. On the west side of this hill, however, this formation appears to be much thinner, and in some places not represented at all. This is again the case farther southwest along the road leading to Howes Cave between Dann's and Sunset hills but on the north slope of the latter hill a good exposure is found [*see* section in ch. 5]. On the whole, the Oriskany sandstone is not well exposed in the Cobleskill valley, and it is not impossible that it is absent over part of this area. On East hill the thickness appears to be not over one or two feet, the highest beds being represented.

While the lack of outcrops can not of course be accepted as conclusive evidence of the absence of this formation in portions of this region, yet the fact that the Oriskany is so eminently fitted to produce extensive outcrops, or at least to influence the topography, lends color to the supposition that where the outcrops are wanting, other conditions being favorable, this formation is either absent, or so thin that it can not exert its normal influence on the progress of erosion. If then we accept the facts as indicating an irregularity in the thickness of this formation, we have additional evidence pointing to an hiatus between the Becraft and Oriskany formations of this region. We may therefore assume that during early Oriskany time the Schoharie as well as the northern Helderberg regions were above water and subject to a certain amount of erosion during which the Port Ewen beds and in places also portions of the upper Becraft were removed, with the exception of the remnant of the former formation found on West hill. During

this period the near shore sand and pebble beds of the lower Oriskany were deposited in the Rondout region and southward and the lower Oriskany beds of Becraft mountain were deposited probably at a greater distance from the shore, so that the silicious element in them became much reduced. As has been shown elsewhere[1] the Oriskany of Becraft mountain is a continuous series with the Helderbergian series, the calcareous Port Ewen beds of that locality forming a complete transition from the one to the other.

Fossils of the Oriskany formation

Brachiopods are the most characteristic fossils of this formation. One of the most striking is Hipparionyx proximus

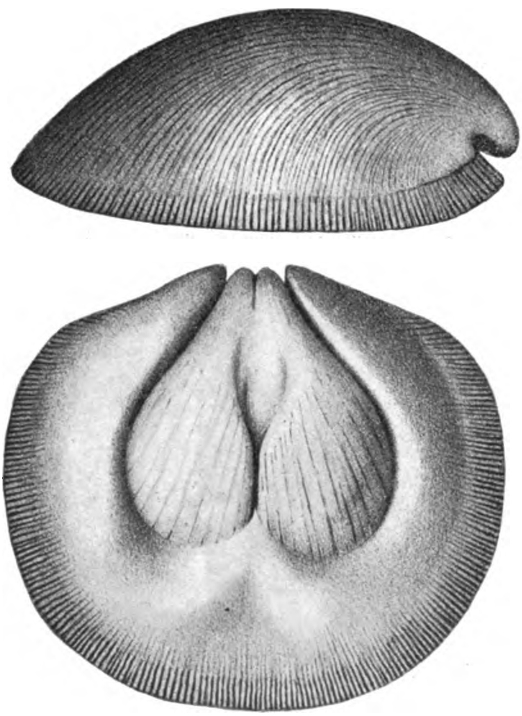


Fig. 75 Hipparionyx proximus

[fig. 75] with its extremely convex brachial and nearly flat pedicle valves, the latter with strong muscular impressions, which have

[1] Stratigraphy of Becraft mountain.

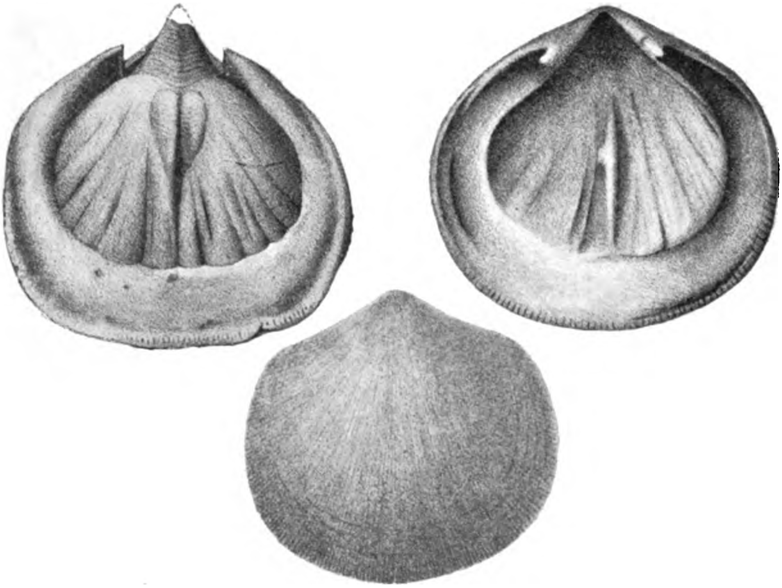


Fig. 76 Rhipidomella musculosa

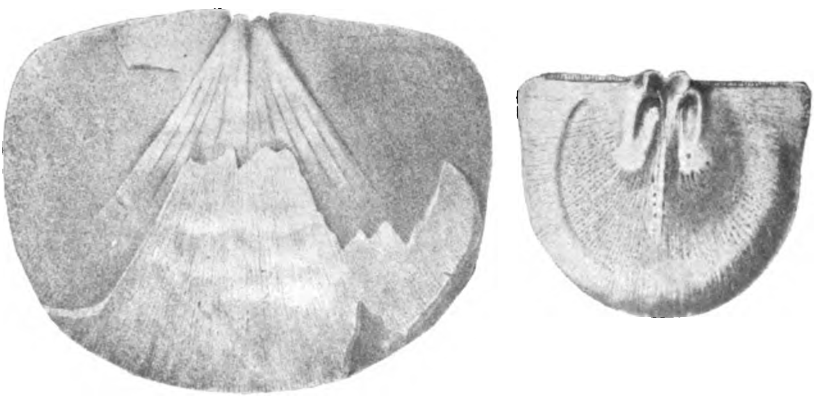


Fig. 77 Leptostrophia magnifica

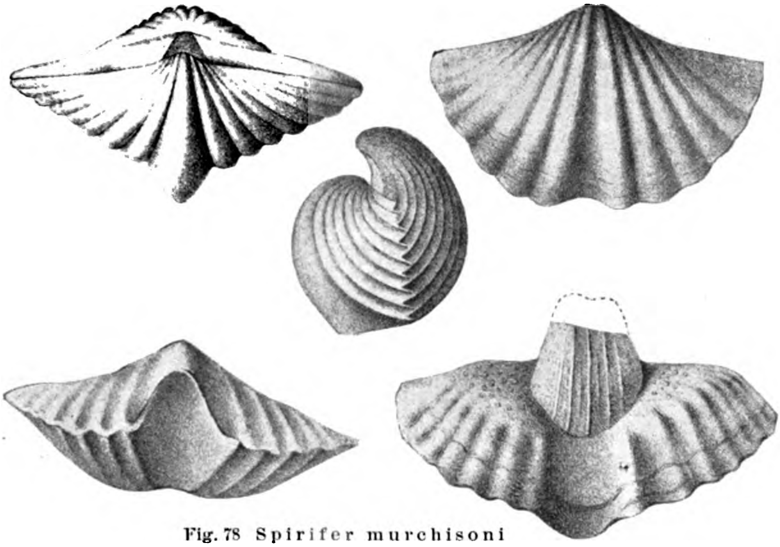


Fig. 78 Spirifer murchisoni

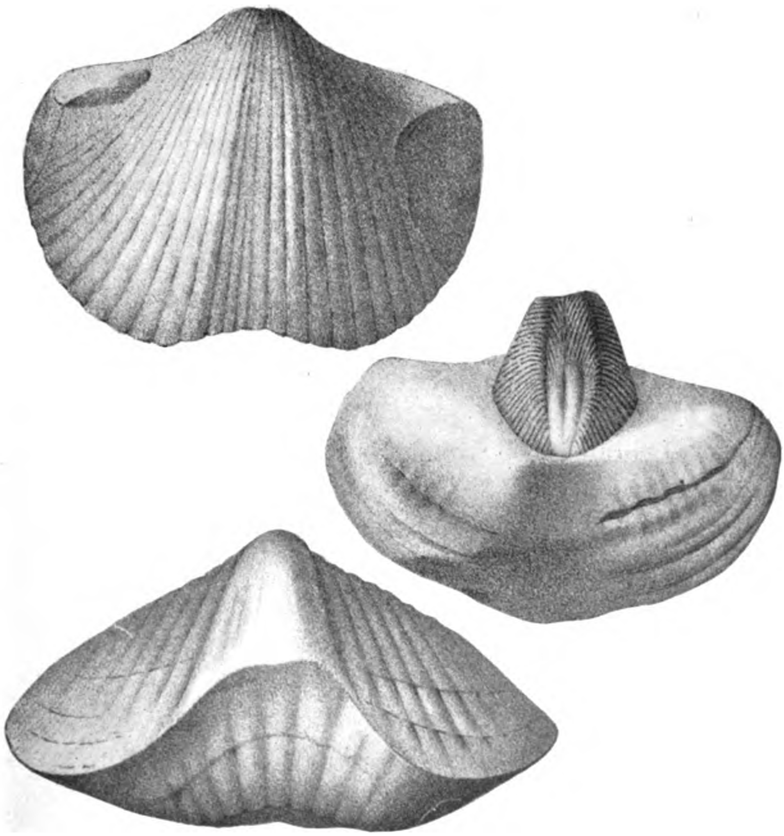


Fig. 79 Spirifer arenosus

been compared with the impression of a colt's foot. Rhipidomella musculosa [fig. 76] is a smaller type, with less marked muscular impressions. Leptostrophia magnifica [fig. 77], a large nearly flat species, with pronounced divergent muscular impressions and fine radiating striae, is likewise common, together with several other species of the genus. Spirifer murchisoni [fig. 78] and S. arenosus [fig. 79] are the most characteristic brachiopods of this formation, the former distinguished by its broad rounded plications, and smooth fold and sinus, the other by its numerous low rounded plications which also extend across the fold and sinus. Internal molds of these two species are characterized by strong elevations in the rostral cavities, which are differently marked in the two species, as shown by the illustrations. Eatonia peculiaris [fig. 80], a small species with a strong anterior deflection, and the surface marked only by fine radiating striae is common. Several large rhynchonelloids occur of which Plethorhyncha barrandei [fig. 81] is the most striking. Others are Plethorhyncha pleiopleura [fig. 82], Camarotoechia oblata [fig. 83] and C. fitchana [fig. 84]. Leptocoelia flabellites [fig. 85] is not uncommon and is the only small plicated shell with flat brachial and moderately convex pedicle valve. One of the most characteristic species of this horizon is the large, elongate, robust Rensselaeria ovoides [fig. 86] readily known by its convexity and regular surface striation. With it occurs the smaller, gently convex Megalanteris ovalis [fig. 87], in which the surface striae seldom appear.

Fig. 80 Eatonia peculiaris

The pelecypods are chiefly represented by the large Pterinea textilis var. arenaria [fig. 88], with its sharp striations; and Pt. gebhardi [fig. 89], with flat, rounded plications.

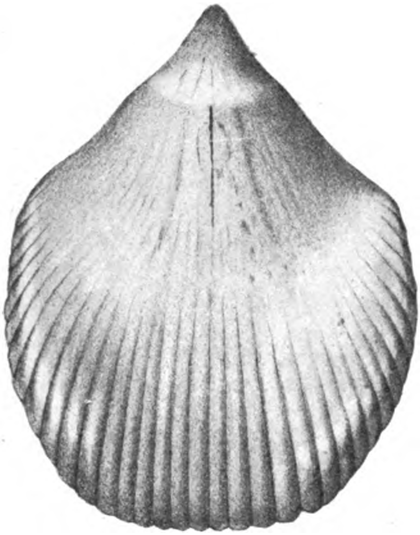


Fig. 81 Plethorhyncha barrandei

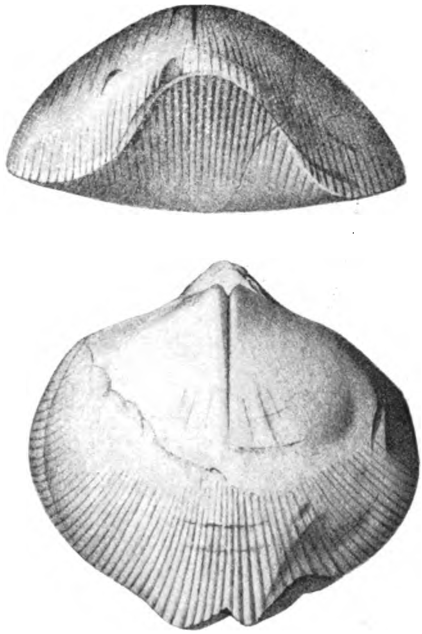


Fig. 83 Camarotoechia oblata

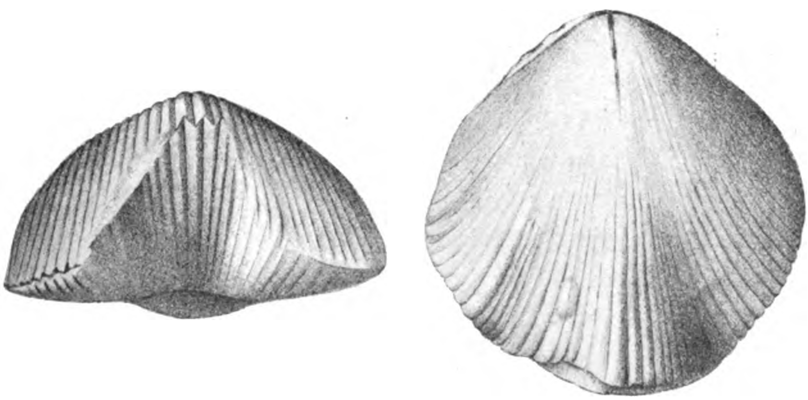


Fig. 82 Plethorhyncha pleiopleura

Fig. 84 Camarotoechia fitchana

Fig. 85 Leptocoelia flabellites

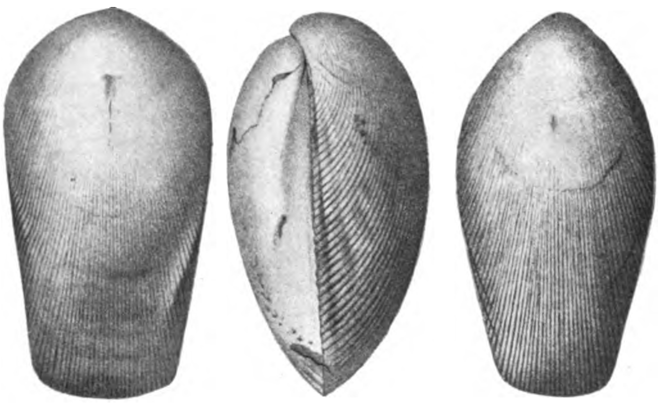


Fig. 86 Rensselaeria ovoides

Fig. 87 Megalanteris ovalis

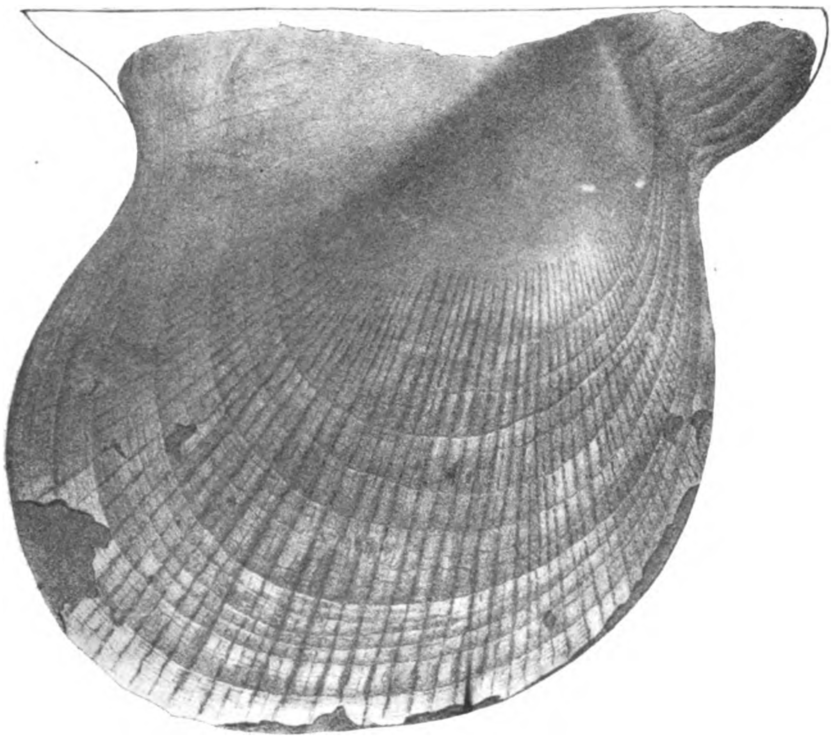


Fig. 88 Pterinea textilis var. arenaria

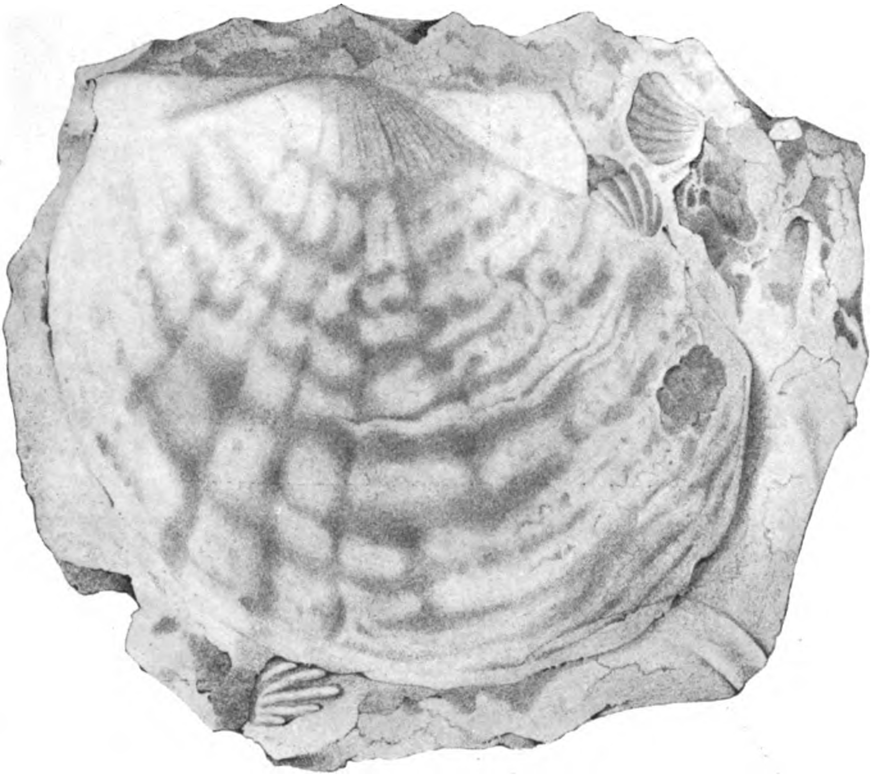


Fig. 89 Pterinea gebhardi

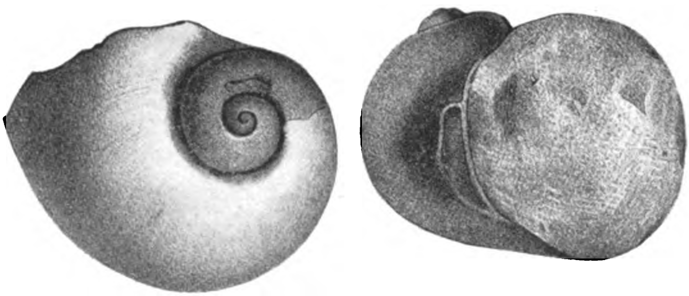


Fig. 90 Diaphorostoma ventricosa

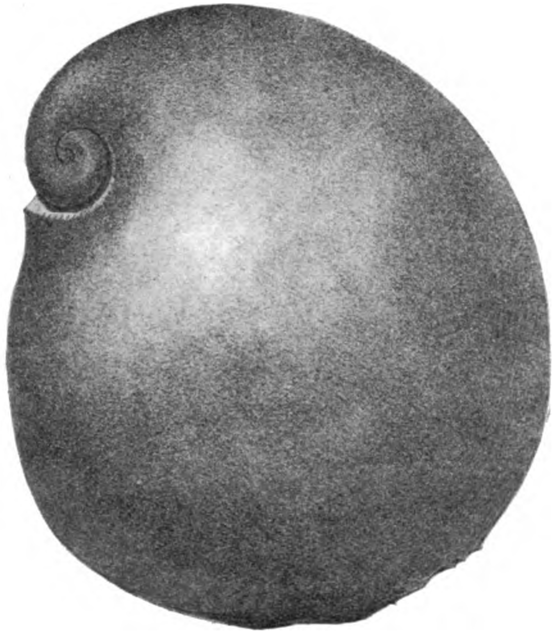


Fig. 91 Strophostylus expansus

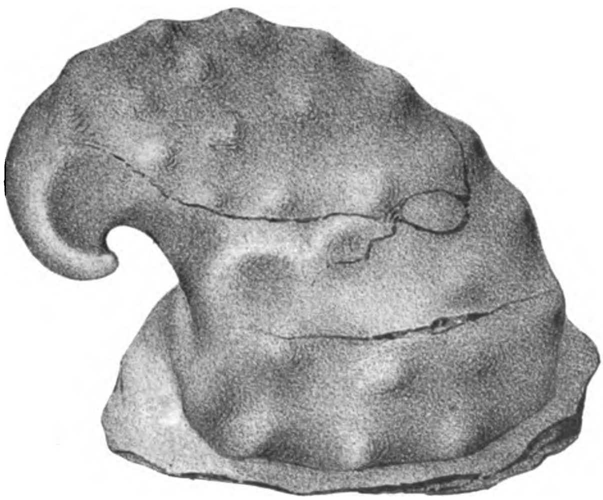


Fig. 92 Platyceras nodosum

Among gastropods the close coiled and extremely rotund Diaphorostoma ventricosa [fig. 90] and Strophostylus expansus [fig. 91] are the most characteristic. A number of species of Platyceras also occurs, P. nodosum [fig. 92] being the most striking.

Esopus shales

Cauda galli grit, cocktail grit

Resting on the wave-marked surface of the upper quartzite bed of the Oriskany of this region we find a dark brown or black silicious or gritty shale of very uniform character and virtually barren of organic remains. This formation is well exposed in the Esopus creek below Saugerties, from which locality it derives its name. Throughout the Helderberg region it maintains a very uniform character, commonly splitting into small rectangular fragments, which cover the slopes of the hillside underlain by it. In the disturbed region south of Saugerties this formation is strongly affected by slaty cleavage, which entirely obliterates all traces of the original bedding, but in the Schoharie region the bedding is readily discernible, specially in fresh exposures of the rock.

There are few exposures of this formation in the Schoharie region, the only opportunity of seeing the lower beds being where artificial excavations have been made. Such an excavation is seen occurring on East hill, on the road which ascends the hill northeast of Schoharie, near where it passes from the Becraft onto the Oriskany [*see* map]. As usual a brief exposure has caused the checking of this rock so that it is mainly a slope of loose material. Near the summit however along the line of contact with the Schoharie and Onondaga beds, large slabs are often found covered with the peculiar markings which, on the supposition that they were seaweeds and owing to the fancied resemblance of the marking as a whole to a rooster's tail, have been named Spirophyton (Taonurus) cauda-galli [fig. 93]. From this structure the rock has received the early name of Cauda-galli grit. It is highly probable however that the structure in question is inorganic, representing wave-marks of a peculiar

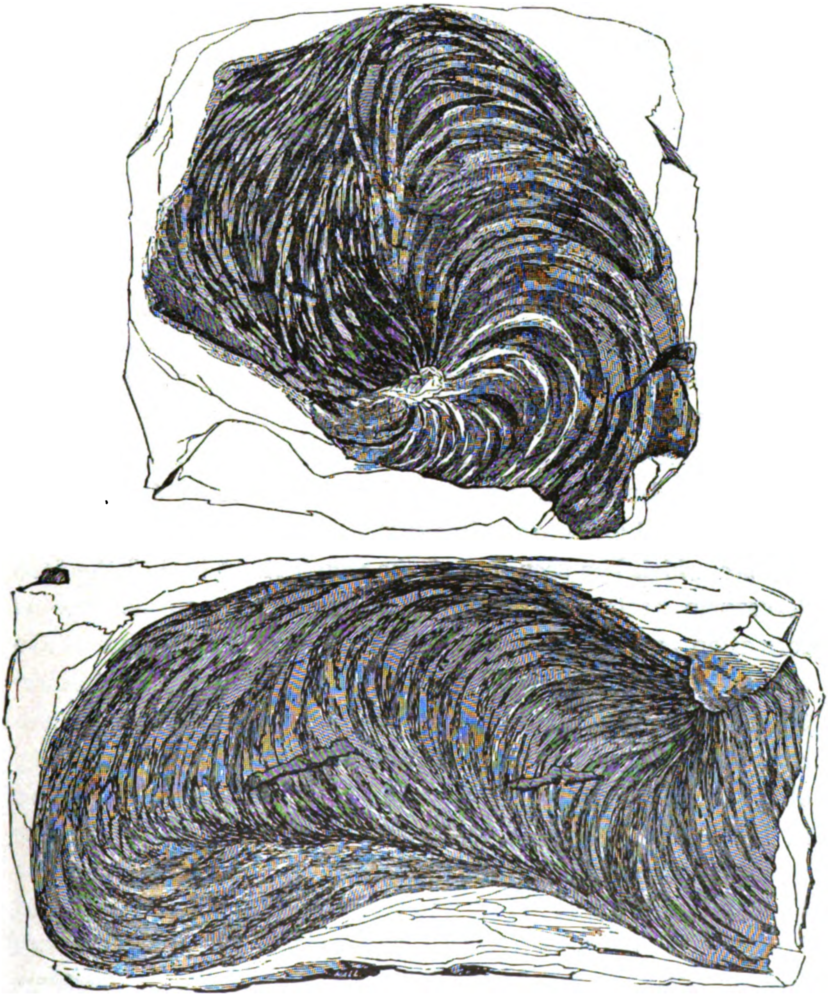


Fig. 93 Spirophyton Taonurus cauda-galli

type. As already noted, similar ones are found on the surface of the upper quartzite of the Oriskany.

The thickness of the Esopus on West hill is scarcely over 90 feet,[1] while on East hill the measurements give only about 80 feet. At Countryman hill near New Salem the thickness of this formation is 121 feet; at Clarksville 121 feet; at Becraft mountain and at Rondout about 300 feet including the Schoharie, and at Port Jervis about 700 feet. Except the structure described as Spirophyton (Taonurus) cauda-galli no fossils have been found in the Esopus shales of this region.

Sequence of events during Lower Devonic time

With the completion of the deposition of the Manlius limestone, i. e. at the end of Siluric time, there appears to have been a general elevation of the North American continent into dry land,[2] with the exception of a long narrow sea, which extended along the western border of the old Appalachian continent (Appalachia) and between it and the newly elevated continent on the west. In this sea which has been named the Cumberland basin,[3] the Helderbergian strata were deposited, resting directly on the Manlius formation and continuous with it in the central portion of the basin. Western New York and the whole Mississippi region, being above sea level at that time, were actively eroded, till at the beginning of Oriskany time, only 7 feet (the Cobleskill member) of the Manlius remained in western New York; from 300–400 feet in Michigan; and not over 30 feet in southeastern Wisconsin where it rests directly on the Guelph.[4] Westward from this point the Manlius, if once present, was entirely removed by erosion, and farther west the whole Siluric is wanting. The fact that late Devonic rests on late Lower Siluric in some localities suggests

[1]These measurements are made by careful leveling from the top of the Oriskany to the base of the Schoharie or the Onondaga [*see* sections in ch. 5]. The thicknesses heretofore published for this formation in the Schoharie region are mostly too large.

[2]The Cayugan emergence of Ulrich and Schuchert.

[3]Ulrich & Schuchert. Paleozoic Seas and Barriers in Eastern North America. N. Y. State Paleontol. An. Rept for 1901. p.647.

[4]These dolomites (Monroe) may in part represent the Salina.

that the Siluric was present and was removed by erosion before the deposition of the Devonic. Thus it would appear that as Helderberg deposition went on, and a gradual westward migration of the shore took place, beyond the limits of the old Cumberland trough higher and higher members of the Helderberg series came to rest, not merely on the upper Manlius as would have been the case had there been no erosion, but on lower and lower beds of the Manlius progressively or on even lower formations.

How far westward in New York the Helderberg invasion extended is not known. The present extent of the formation is of course no index to its former maximum extent, for subsequent erosion may have removed a large portion of this series of formations. No actual shore deposits have been located in any of the present typical outcrops of the Helderberg in New York, either east or west, and from this we may argue that the former shores of the Cumberland basin were at a considerable distance east and west from the present extent of the formation. If the higher members of the formation, i. e. the beds of Becraft and Port Ewen age, ever extended over central New York they were entirely removed by erosion before Onondaga time, for the Onondaga formation rests on the Manlius at Cayuga lake with only a representative of the Oriskany intervening. On the whole it seems that the Helderberg transgression could not have been a very markedly westerly one, inasmuch as the evidences for westward overlap are meager.

Examples of overlap of the Helderberg beds on lower formations are known from only a few localities within the State of New York. One of them is a short distance north of Warwick on the Lehigh and Hudson River railroad in southern Orange county. Here Kemp and Hollick[1] record a purplish shale resting on cherty Cambro-Champlainic limestone, and containing fossils possibly of New Scotland age. South of Cornwall station on the Erie railroad in Orange co. highly fossiliferous New Scotland shales rest on the Longwood (Salina) shales. The possibility of a fault in

[1] N. Y. Acad. Sci. Ann. 7:650.

this region must however be considered.[1] These two examples represent overlaps on the eastern shore of the central Helderbergian sea (Cumberland channel).[2]

In the northern region a good example of overlap is seen in the Helderberg outlier of St Helen's island in the St Lawrence river, opposite Montreal.[3] Here a limestone with upper Helderbergian (Becraft-Port Ewen) fossils rests directly on the Utica beds. The fauna of this limestone is in part suggestive of the Oriskany, thus showing these beds to be very late Helderbergian. This overlap marks the neighborhood of the western shore of the Helderberg sea in that region. Schuchert thinks that "there is no clear evidence that the Albany county, N. Y., area ever connected with Montreal by way of the Champlain valley, as was supposed by Logan and Dana to be the case."[4] No real reason is known to me why these areas need be considered distinct, since the Champlain region has been peneplained down to the Champlainic, and any Helderbergian beds formerly existing here would be removed by erosion. The similarity between the St Helen's Island, and New York Helderberg faunas suggests a direct connection; the elements of difference between these faunas indicate that the connection was by a narrow channel.

The fauna of the Square lake limestone of Aroostook county, Me.[5] suggests a relationship with the upper beds of the Helderbergian of the New York areas. However, several species unknown in the New York Helderberg are found here, and link the fauna more closely with that of Gaspé. Whether the faunal difference is such as to require placing this eastern fauna in a separate basin, or whether the difference of the faunas is to be

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[1] *See* Ries, N. Y. State Geol. 15th An Rep't, p. 427. I am indebted to Mr C. A. Hartnagel for calling my attention to this and the preceding occurrence.

[2] The Rensselaer grit of eastern New York may represent the overlapping clastic margin of the Helderberg rocks resting on upturned and eroded Cambric and Champlainic beds.

[3] Schuchert. Am. Geol. 1901. 27:245.

[4] More recently Professor Schuchert has expressed the belief in a channel in the Connecticut valley region (Private letter).

[5] *See* Billings, Portland Soc. Nat. Hist. Proc. v. 1. 1863; Williams, H. S. U. S. Geol. Sur. Bul. 165.

explained by difference in the character of the water bodies— the northeastern, an embayment from the open sea; the more southern, a long narrow channel—is a problem still unsolved. Studies now in progress of these northern faunas by the state geologist, promise to clear up these obscure points.[1]

In eastern and central Pennsylvania the Stormville shales and sandstones replace the upper part of the Helderberg limestones. They rest on the Stormville limestone, which represents the Manlius, and in part the Coeymans, as indicated by the abundance of Sieberella galeata in the upper beds. Between the two, there is a marked break, generally indicated by conglomeratic beds at the base of the overlying series. These often become nearly pure quartz conglomerates. On the north branch of the Susquehanna in central Pennsylvania (Grove quarry section), the Stormville limestone is succeeded by 4 feet of quartz conglomerate and this by 100 feet of Stormville shales containing a New Scotland fauna. The Stormville limestone here appears to represent the Manlius and lower beds to the base of the Decker Ferry series. We have therefore an overlap of the New Scotland on the Manlius. About 100 miles east of this section, at Stormville, near the Delaware river, the Stormville shale 160 feet thick and containing a New Scotland fauna, rests on a calcareous sandstone with quartz pebbles, below which are fragmental beds largely calcareous, but frequently containing quartz pebbles. In some of these beds Sieberella galeata abounds, while the limestone below also contains this species in abundance near the top. Here the Stormville limestone includes a part of the Coeymans as well. Farther northeast, near Hainesville N. J., the Stormville sandstone is a thin bed at the top of the Coeymans.

In Perry county, Pa., the Tentaculite limestone (Manlius) is overlain by nearly 90 feet of flint shales, the upper 10 feet of which carry New Scotland fossils. Above this lies the Oriskany.

[1] Clarke, John M. Percé. N. Y. State Paleontol. An. Rep't for 1903.

This therefore must be considered not far from the southern boundary of the Helderberg sea.

What appears to be another case of overlap of the upper beds to the east, is found near Big Stone Gap and other portions of southwestern Virginia. Here a coarse sandstone is succeeded by 70 feet of limestone, silicious at the base but porous upward, when a bed with Leperditia occurs. This is probably the Manlius. Above this are coarse grained calcareous sandstones made up largely of Orthis oblata, Camarotoechia ventricosa and Meristella. This appears to be late New Scotland, which here rests by overlap on the Manlius. Above the sandstones are cherty limestones (the Hancock limestone of the Estillville and Bristol folios) with crinoid stems, Aspidocrinus scutelliformis, Chaetetes, Favosites, Atrypa reticularis, Leptaena rhomboidalis, Stropheodonta, Spirifer cyclopterus, Meristella, Camarotoechia nucleolata, Orthis oblata and others. This also represents late New Scotland or early Becraft time. The thickness of these two beds is not much over 150 feet. Above them lie 35–40 feet of coarse reddish sandstone of Oriskany age, containing Hipparionyx proximus, Meristella lata, etc.[1]

Near Perryville Tenn. the Linden limestone rests on the Meniscus limestone or Brownsport bed.[2] The Linden contains a fauna suggestive of New Scotland or later age and is succeeded by the Camden chert of Oriskany age. The base of the Linden shows no marked unconformity so far as known, but appears to be a crinoidal lime sandrock. The Brownsport may be the equivalent of the Decker Ferry and other beds of Salina age, and in part may also represent the Manlius.

In southeastern Illinois and in Missouri the upper part of the Clear Creek limestone contains an upper Helderbergian fauna,

[1] Stevenson. Am. Phil. Soc. Proc. 1880–81. 19:98, 234.
[2] Foerste, A. F. Jour. Geol. 11:581, 680.

the lower portion being most probably the equivalent of the Brownsport of Tennessee. No unconformity has been reported between these two members, but it probably exists.

In Indian Territory, in the region of the McAllister coal field, limestones apparently of the age of the New Scotland are found resting on a bed with a Niagaran fauna. No unconformity is recorded between the two, but here, too, one probably exists. Besides the New Scotland species which this region has in common with New York, other species unknown in the northern region occur. Some of these have also been found in the Linden beds of Tennessee, with which these beds are closely related.

Considering all the evidence adduced, it appears that the southwestern region was not covered by the Helderberg sea till late Helderbergian time, while perhaps the Becraft and Port Ewen beds were deposited in the New York area. The southern element of the fauna unknown in New York, suggests a probable southward connection with the Atlantic ocean. North of the area depicted, the western shore line may have extended north of the Gaspé peninsula and across the North Atlantic along what has been termed the Hercynian chain of elevation, which thus connected the American seas with those of early Devonic time in Europe.

At the end of Helderbergian time there appears to have occurred another elevation of unknown magnitude which brought portions of the Helderberg series above water level, when they became subjected to erosion. The succeeding early Oriskany sea was therefore restricted to the eastern portion of the Helderberg sea. When the westward transgression of the Oriskany sea occurred the subsiding land surface was more or less irregular and not everywhere made by the same formation. Thus while in the east the lower Oriskany beds rest on the Port Ewen, the upper member of the Helderbergian, in the Schoharie region and the northern Helderbergs, higher Oriskany strata rest on the Becraft. At Litchfield in Herkimer county they rest on the Coeymans (?), in central New York on the Manlius, and

in western New York and Canada on the Cobleskill. In western Maryland the Oriskany is 350 feet thick, and rests on the New Scotland which itself is only 64 feet thick, while the Becraft is absent altogether. In many localities in New York and elsewhere the unconformity at the base of the Oriskany is emphasized by the fact that the lower beds are conglomeratic and contain fragments of the underlying limestones.[1]

Clarke has suggested that the Oriskany of Becraft mountain is merely the deeper water facies of the normal Oriskany which is typically developed in the northern Helderbergs and the Schoharie region. The fossils of the type locality, Oriskany Falls N. Y. are considered by Clarke as not indigenous, the character of the deposit indicating a habitat unfavorable for the large brachiopods found in the rock. In the townships of Oneida and North Cayuga Ont., 50 miles west of Buffalo, a remarkable assemblage of fossils occurs in the Oriskany beds, which Schuchert has regarded as forming a typical late Oriskany fauna (Decewville). The strata here rest unconformably on the Lower Manlius which, as at Buffalo, is traversed by sandstone dikes, and they are immediately succeeded by the Onondaga limestone. The corals of the latter are mingled with the fossils of this phase of the Oriskany in such a manner that except for the lithic dissimilarity of the two formations, they could not be separated. Out of the 71 species found in these Decewville beds "not less than 42 pass up from the lower horizon into the Onondaga."[2] On account of the marked Onondaga aspect of the fauna, Schuchert holds that it is unwise to call these Ontario beds Oriskany any longer, and has proposed the name Decewville for it, from the nearest village, which in turn bears the name of the early describer of these beds, John DeCew.

The absence of the normal (Schoharie county) Oriskany in western New York and at Cayuga Ont. is readily explained by

[1] *See* Rogers, W. B. Am. Jour. Sci. 1842. 43:181, for examples of pronounced unconformity and evidence of erosion at the base of the Oriskany in Pennsylvania.

[2] Schuchert. *Loc. cit.* 1902. p. 653.

the progressive westward overlapping of higher and higher Oriskany strata, the highest of which only, with its modified fauna, reached this western region, long after the normal Oriskany fauna had died out in eastern New York. Clarke[1] has described the character of these deposits across New York State as lenses of sand spread upon a comparatively even sea floor. In one lens, the thickness reached is 18 feet, in other localities the formation has thinned away altogether. This, as Clarke has shown, is in conformity with the characteristics of an advancing shore line. The absence of upper Oriskany beds with a fauna corresponding to that of the Decewville beds in the east, is more difficult to explain, unless we regard the Esopus shales as their stratic equivalents, though representing an Appalachian type of deposit in which the Oriskany fauna could not exist. The Decewville and Esopus deposits would thus represent two distinct subprovinces of the late Oriskany sea, the first a deeper water and the second a shallow water type of deposit. If we accept this as the true explanation we can understand the absence of the Esopus throughout the west, which otherwise is explainable only by an hiatus. It also does away with the necessity of supposing that there is an unrepresented hiatus between the Oriskany and the Esopus in the Schoharie and Helderberg regions which marks the time during which the Decewville beds were laid down. There certainly is no evidence of an erosion interval between the Oriskany and Esopus of this region, for everywhere the surface of the Oriskany is formed by the same hard quartzite. Nor is there any apparent evidence of a break between the Oriskany and Onondaga in the Cayuga Ont. region; the association of the two faunas is so intimate. We might of course assume that the Oriskany faunas (i. e. of Becraft Mt, Schoharie and Decewville) were contemporaneous, but flourished in separate provinces of the interior sea. In that case the absence of the Esopus from the western region must be explained by assuming a stratic unconformity between the Decewville–Oriskany and Onondaga. On the whole

[1] Amer. Ass. Adv. Sci. Proc., 49:188.

with our present knowledge of the facts, the theory here set forth,[1] which regards the Esopus of any given region as the time equivalent of the Oriskany from the Decewville formation, (including perhaps as Schuchert suggested, the typical Schoharie as a late eastern phase of the Decewville) down to the phase of Oriskany represented at the region in question, seems the most satisfactory. Thus at Becraft mountain, where about 200 feet of Esopus succeed the Oriskany, which here is lower Oriskany as shown by stratigraphy[2] and paleontology,[3] the Esopus represents all of the later Oriskany to the top of the Decewville. But where, as at Schoharie, the Esopus rests on typical middle Oriskany, it represents only the upper part of the Esopus of Becraft mountain, as is further shown by the diminished thickness (90 ft).[4]

These facts do not do away with the formational name Esopus, or Schoharie, any more than the name Marcellus can be abolished as a formational one, although westward it is represented by the upper Onondaga and lower Hamilton. The same relationship is again seen in the Oneonta sandstone and the Portage shales and in the Catskill sandstones and shales and the Chemung shales.

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[1] Professor Clarke has called my attention to the fact that Frech (Lethaea Palaeozoica II, p. 208-9) has previously outlined this general conception. Frech however represents the Lower Oriskany as existing in the western region, where judging from his diagram (p. 209), he makes his shore zone throughout Oriskany-Onondaga time, his formations being mostly clastic (sandstones, etc.) in the west, and shading off through the argillaceous Esopus and Schoharie to calcareous deposits in the east. The Schoharie is considered by Frech to be the shore equivalent of the Onondaga. Ulrich and Schuchert likewise believe in the general equivalency of the Decewville and Esopus (N. Y. State Mus. Bul. 52, p. 658, tab.).

[2] Grabau, A. W. Stratigraphy of Becraft Mountain.

[3] Clarke, J. M. Oriskany fauna of Becraft Mountain.

[4] If the Camden Oriskany is of an earlier type than the Oriskany of Becraft mountain, it must represent an early Oriskany invasion while late Helderbergian (Port Ewen) deposits were still laid down in the northern part of the Cumberland sea, since there is no faunal or stratic break between the Oriskany and Port Ewan of Becraft mountain, nor between the Port Ewan and Becraft formations of the same locality.

The relationship here suggested is shown in the following diagram [fig. 94].

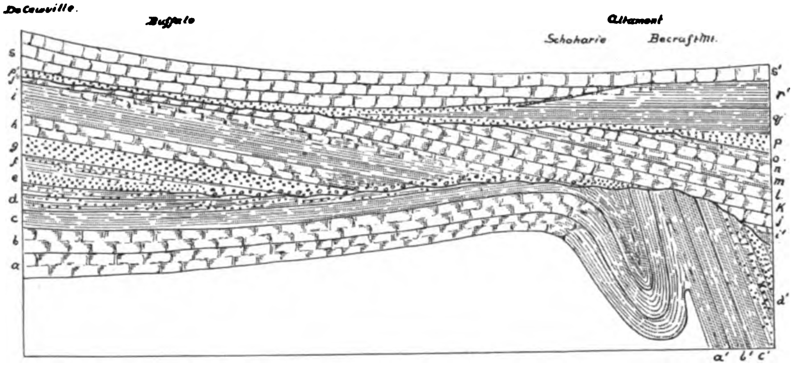


Fig. 94 Diagram of the relationship of the Champlainic, Siluric and early Devonic strata of New York. *a*=Beekmantown, *a'*=Deep kill shales, *b*=Black river-Trenton, *b'*=Normanskill shale, *c*=Utica shale, *d*, *d'*=Lorraine, *e*, *e'*=Oneida-Shawangunk transgressional conglomerate, *f*=Medina shales, *g*=Medina sandstones, *h*=Clinton-Niagara, *i*=Salina-Bertie-Rosendale, *j*=Cobleskill-Rondout, *k*=Manlius, *l*=Coeymans, *m*=New Scotland, *n*=Becraft, *o*=Port Ewen, *p*=Oriskany, *p'*=Decewville, *q*=Esopus, *r*=Schoharie grit, *r'*=Schoharie shale, *s*, *s'*=Onondaga limestone

Chapter 4

STRATIGRAPHY OF THE SCHOHARIE REGION (continued)

Middle and Upper Devonic strata

The succession of the Devonic formations above the Esopus shale is as follows in this region:

Upper Devonic	Catskill	(Chemung)
	Oneonta	(Portage)
	Sherburne	
Middle Devonic	Hamilton	
	Marcellus	
	Onondaga	
	Schoharie	
Lower Devonic	Esopus, etc.	

These will be described in ascending order:

Schoharie grit

This formation is characteristically developed only in the Schoharie valley and at several points along the northern Helderbergs. It is a silicious limestone, compact, mud-textured when fresh and of a dark bluish gray color, somewhat like the Upper Oriskany. It effervesces readily with acid and weathers by solution of the lime into a brown porous sandrock not affected by acid and in which the fossils remain as molds. Fragments of this rock are commonly found scattered about on the Esopus slope but outcrops of this formation are rare. The best opportunity for the study of this rock is found on the northern end of both West and East hills, the latter being the most accessible. The best exposures are found above the road which runs along the northern slope of East hill near the cross road which turns down the hill to Shutter's Corners [map: XII g, 43]. Some portions of the rock are rather shaly and sparingly fossiliferous. No measurements of the thickness are possible with the present imperfect exposures; the best estimate that can be made is 5 or 6 feet. Eastward, beds carrying the fossils of the Schoharie are much thicker. At

Becraft mountain 150 to 200 feet of strata, lithically similar to the Esopus, but more cleaved, are referred to the Schoharie formation, since some of the characteristic fossils have been found in them.

Fossils of the Schoharie grit

In chapter 7, 123 species of fossils are listed from this formation. ·Of these 103 species have been found in the Schoharie

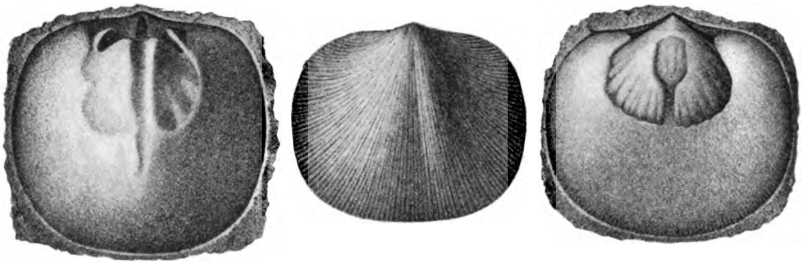


Fig. 95 Rhipidomella alsa

region, the remainder being from Albany county. Of the total number, 43 pass upward into the Onondaga and sometimes higher, leaving a total of 77 species confined to this horizon. Of these the mollusks are the most striking, particularly the cephalopods, of which a total of 43 species are included in the list, 39 of which have not been recorded from higher horizons.

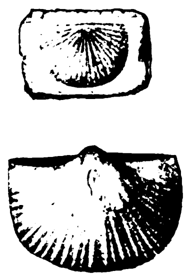


Fig. 96 Stropheodonta parva

Among the brachiopods the following may be noted: Rhipidomella alsa [fig. 95], distinguished by its long hinge line, more convex brachial valve with depression down the center, and bifurcating striae; Stropheodonta parva [fig. 96], characterized in the mold by strong subangular costae, which become grooved and increased by intercalation on the lower part; Leptostrophia perplana [fig. 97]; recognized by its flat surface, fine striae and diverging depressed lines in the mold of the beak of the pedicle valve; Strophonella

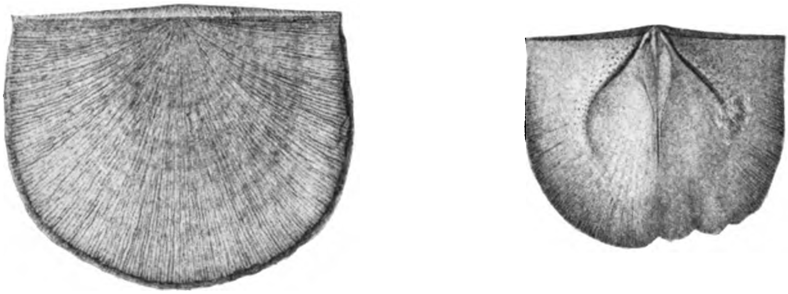


Fig. 97 Leptostrophia perplana

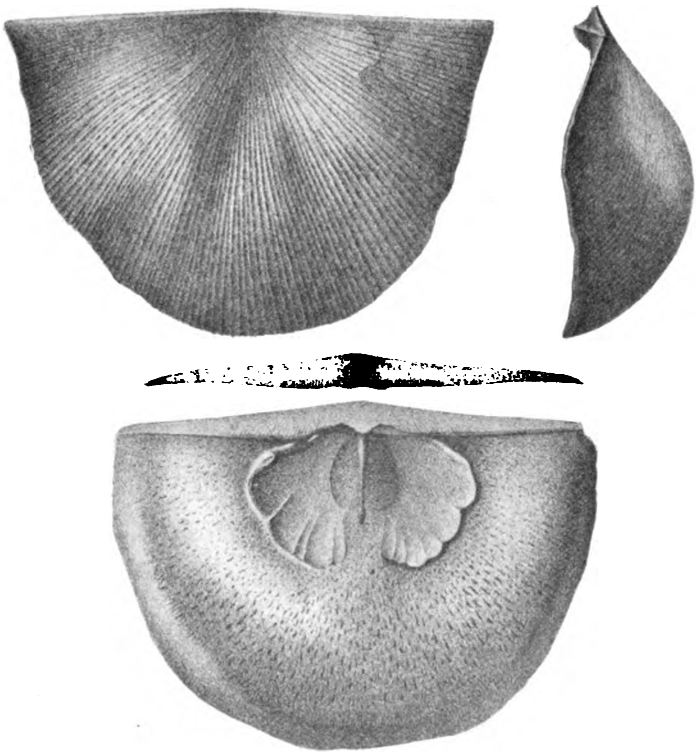


Fig. 98 Strophonella ampla

ampla [fig. 98], the largest of these brachiopods, characterized by its reversed form and strong rugose striae; Meristella nasuta [fig. 99], abundantly represented by molds of the interior in which the muscular scar and the marks of the strong dental plates are most conspicuous; Pentamerella arata [fig. 100], marked by the overarching beak of the pedicle valve and the strong angular plications and Atrypa impressa [fig. 101], an extremely convex form with a flattening on the center of the ventricose brachial valve, with bifurcating radii, and

Fig. 99 Meristella nasuta

strongly marked muscular impression shown in the internal mold, the most common condition of preservation of the shell.

The pelecypods are represented by a number of species. Among these are Goniophora perangulata [fig. 102], characterized by an extremely sharp umbonal ridge, above which the shell is concave; Conocardium cuneus [fig. 103], recognized by its form and sharp radii; and Panenka dichotoma [fig. 104], characterized by a prominent beak and often by bifurcating radii.

The common gastropods are: Pleurotomaria arata [fig. 105], chiefly represented by internal molds, and readily recognized by their form, low spire, depressed rounded whorls and deep and large umbilicus; Bellerophon curvilineatus [fig. 106], with a discoidal form, sharp peripheral

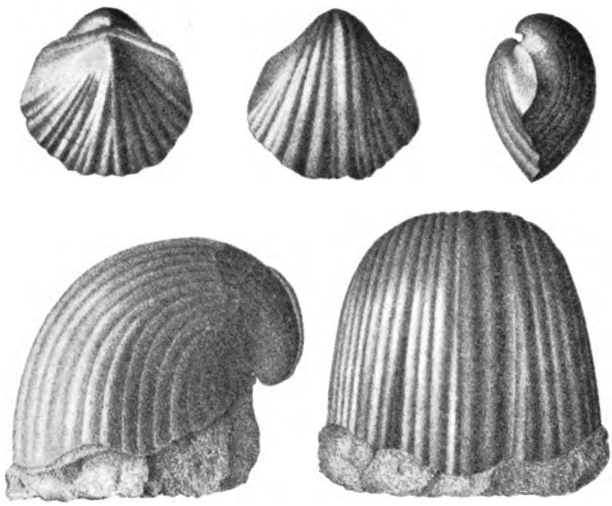


Fig. 100 Pentamerella arata

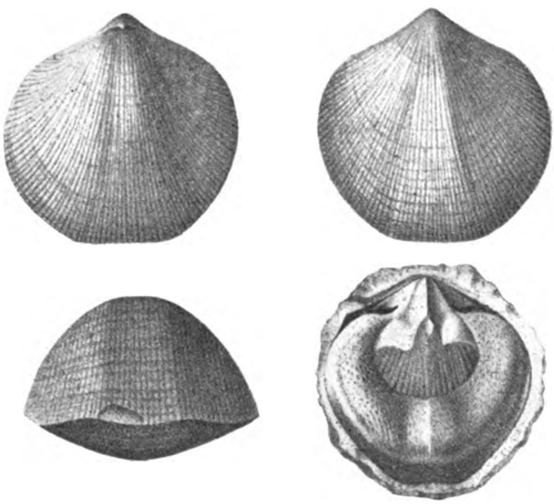


Fig. 101 Atrypa impressa

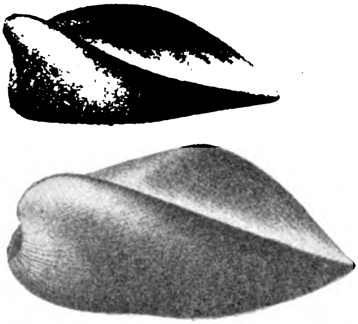


Fig. 102 Goniophora perangulata

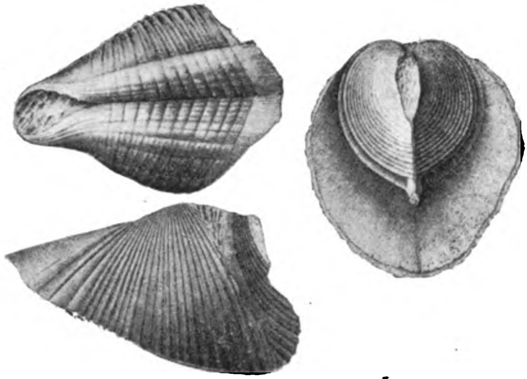


Fig. 103 Conocardium cuneus

Fig. 104 Panenka dichotoma

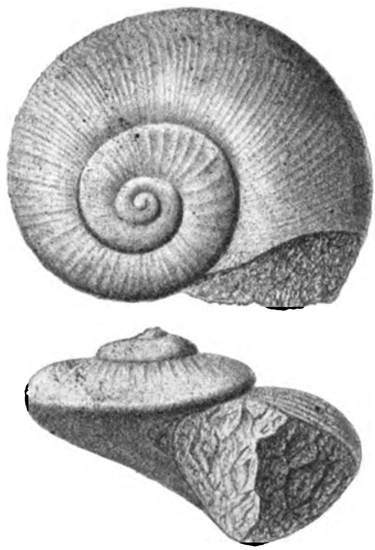


Fig. 105 Pleurotomaria arata

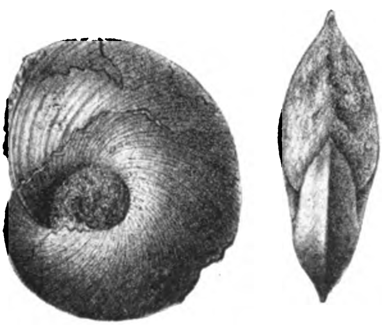


Fig. 106 Bellerophon curvilineatus

carination and strongly backward curving lines of growth; and B. pelops [fig. 107] with a broadly rounded but keeled periphery.

The cephalopods are specially well represented in the Schoharie grit, the orthoceratites being most characteristic.

With the passage of this rock into a limestone (the Onondaga) the occurrence of orthoceratites almost entirely ceases, at least in the eastern part of the state.

Notwithstanding the number of species, and the great number of individuals, a very small proportion of the whole preserves the surface markings. They are almost invariably in the condition of casts of the interior, the shell having been dissolved by the

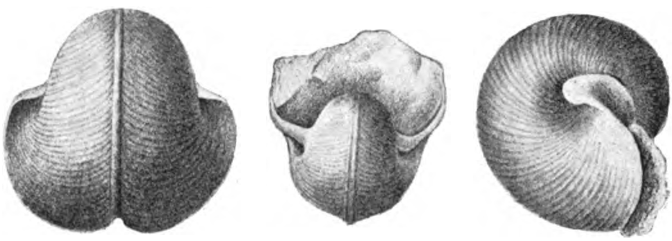


Fig. 107 Bellerophon pelops

percolation of water through the coarse material of the rock. In some examples, where the rock is less charged with arenaceous [silicious] matter, the matrix adheres so closely, seemingly cemented to the fossil, that no satisfactory evidence of surface markings can be obtained. It is rarely possible to determine the character or thickness of the exterior shell of the orthoceratites in the Schoharie grit. The septa are extremely thin, often broken or distorted, through the process of filling with sediment, while the external form of the shell is preserved. The siphuncle, though usually well marked in its passage through the septa, is rarely to be found in the intermediate space, and, in the best examples, is only partially preserved. Specimens which have been cut longitudinally directly through the siphuncle, as shown on the septa at the two extremities, preserve no evidence of that organ in its passage through the chambers, and only a simple mark or notch in the intermediate septa. We can account for this absence only upon the supposition that the tube has been so thin that its walls have been dissolved or broken away during the process of filling the cavity with the surrounding sediment.

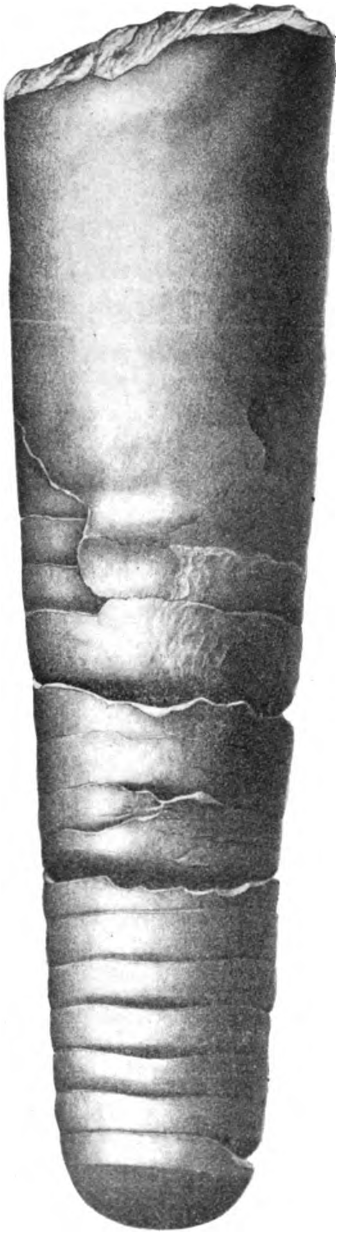


Fig. 108 Orthoceras pelops

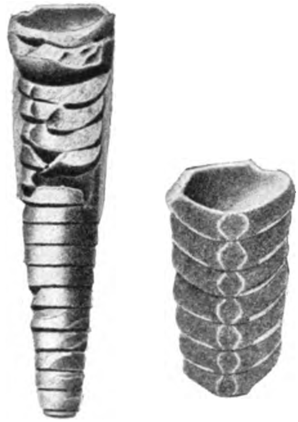


Fig. 109 Orthoceras luxum

Fig. 110 Orthoceras stylus

Fig. 111 Orthoceras pravum

In many cases it appears as if the siphuncular tube may have been absorbed or otherwise removed before the filling of the cavity began.[1]

Among the more abundant species are:

Orthoceras pelops [fig. 108], a large robust species with nearly or quite central siphuncle and strongly convex septa;

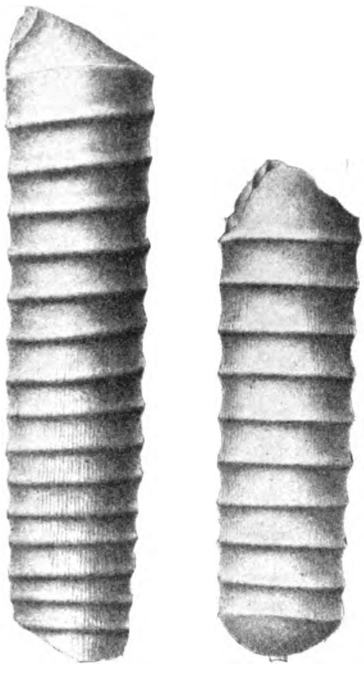


Fig. 112 Orthoceras thoas

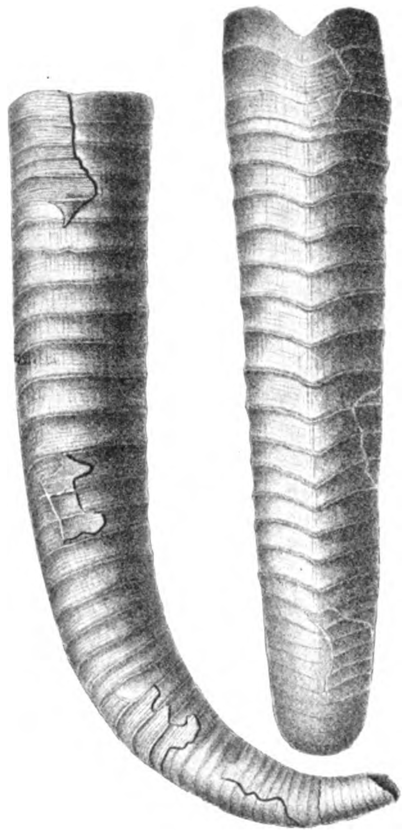


Fig. 113 Cyrtoceras eugenium

O. (Actinoceras?) luxum [fig. 109], the most abundant species, characterized by moderately tapering form, close-set septa and expansion of siphuncle between the septa, as well as interseptal organic deposits; O. stylus [fig. 110], easily recog-

[1] Hall, James. Palaeontology of New York. v.5, pt2, p.228.

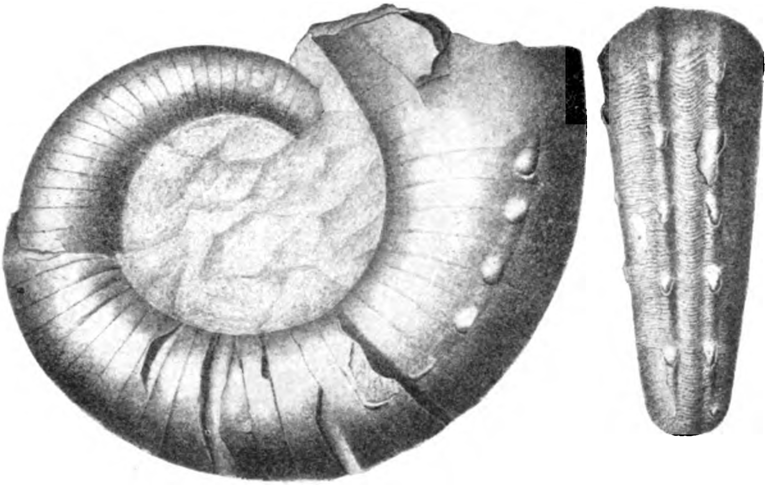


Fig. 114 Gyroceras spinosum

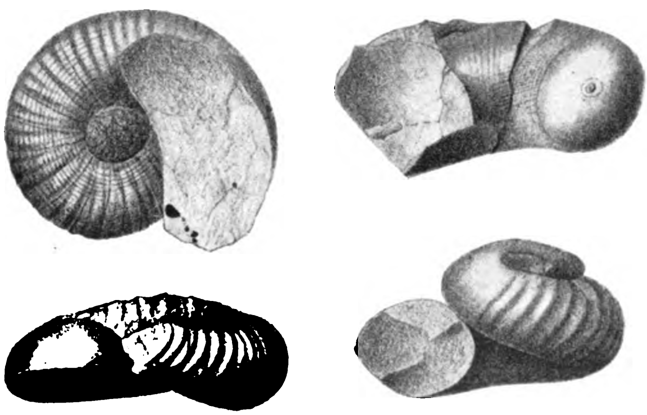


Fig. 115 Trochoceras clio

nized by its almost cylindric and very slender form; O. pravum [fig. 111], distinguished from the preceding by its larger size and widely separated septa and O. (Cycloceras ?) thoas [fig. 112], a cylindric annulated species, with deep camerae and moniliform siphuncle.

Among the cyrtoceratites, or curved cephalopods, Cyrtoceras (Rhizoceras) eugenium [fig. 113] easily ranks first in point of abundance. It is a long, slender form with a gentle curvature and slightly elliptic cross-section. The surface is marked by regular and prominent foliate ridges or expansions of the shell which are strongly deflected backward in a hyponomic sinus on the ventral or outside surface of the curved shell. Between the folds are fine transverse and longitudinal striae. The gyroceracones or loose-coiled nautiloids are represented by Gyroceras spinosum [fig. 114], which is easily known by the spinose ventral ridges and the additional row of tubular spines on either side of the venter. The torticones, finally, or those in which the coil is not in a single plane are represented among many others by Trochoceras clio [fig. 115], a left-handed or sinistral loose coil of about three volutions which enlarge gradually and leave a moderate umbilicus at the base, while the surface is marked by numerous, rather faint, rounded annulations crossed in well preserved specimens by sharp longitudinal striae. Tr. (Pteroceras?) eugenium [fig. 116], in which the whorls expand more rapidly than in the preceding and the surface is free from crenulation, is also among the more common species of this type.

Fig. 116 Trochoceras eugenium

Trilobites are well represented in the Schoharie grit. Calymmene platys [fig. 117], the last and the largest of the genus, differs so little from its predecessor in the Niagaran that differ-

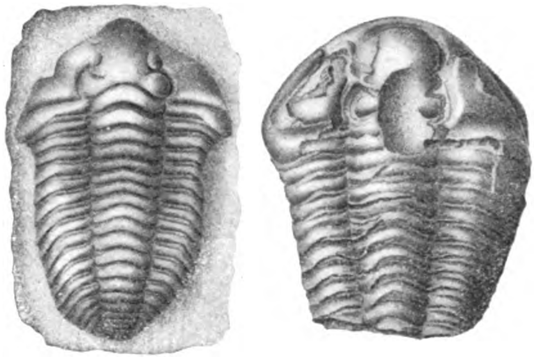


Fig. 117 Calymmene platys

ence in size is almost the only notable character. The hypostomae of the two species are, however, quite distinct. Another characteristic type is Phacops cristata [fig. 118], distinguished from other species of the genus by the axial row of spines which

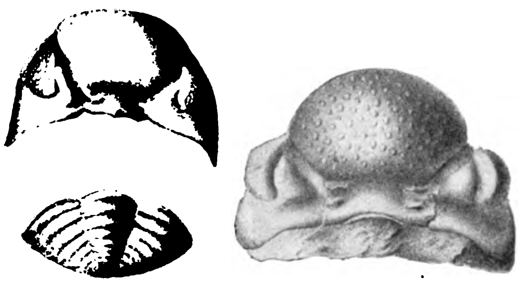


Fig. 118 Phacops cristata

extend as far as the pygidium, the short stout spines on the genal angles, the strongly protuberant glabella, and the dichotomous division in the annulations of the pygidium. Dalmanites anchiops var. armatus [fig. 119] is largely represented by pygidia, the form of which, together with the upcurving basal spine, is characteristic. The head or cephalon when well pre-

served shows a coarsely pustulose glabella, which has a very wide anterior lobe and is subpentagonal in outline; prominent crescentic eyes, stout genal spines and a strong moderately long central or occipital spine are further characteristics. Proetus crassimarginatus [fig. 120] is likewise chiefly represented by pygidia, the small size, regular curvature and marginal rim of which easily characterize it. The large, smooth glabella with very small posterior lobes is also readily distinguished.

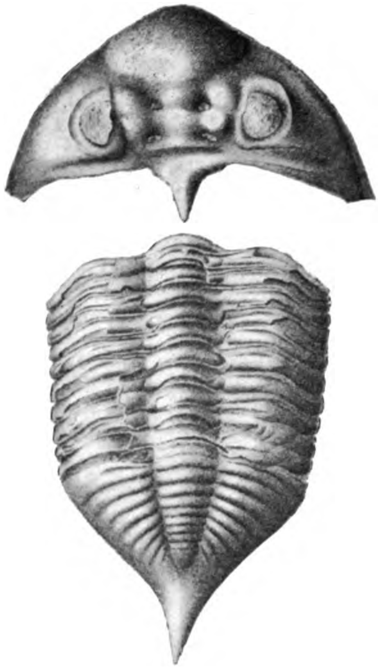


Fig. 119 Dalmanites anchiops var. armatus

Schuchert has suggested the possible equivalency of the Schoharie grit with the Decewville beds of the Upper Oriskany of Cayuga, Ont. He holds that a careful analysis of the fauna may show an intermingling of derived Oriskany with normal Onondaga species. In the list of species from the Schoharie given in chapter 7, those also found in Decewville beds are designated by a double dagger (‡). Of the 123 Schoharie species only 17 are so far recorded from the Decewville beds, and of these, 12 are also found in the normal Onondaga. It will be noticed that the cephalopod element is a new feature in the Devonic faunas of North America, and this is so far unknown in the Decewville beds.

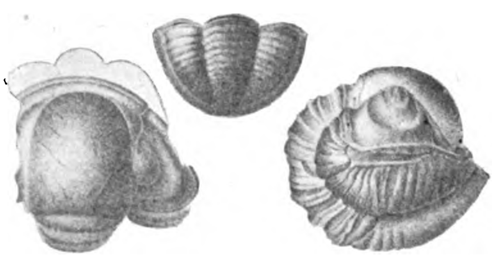


Fig. 120 Proetus crassimarginatus

Onondaga limestone

The Schoharie grit passes upward by imperceptible stages into a moderately pure limestone of grayish color and arenaceous or muddy texture. Chert nodules are common but fossils are not very abundant in the outcrops of this formation about Schoharie. The rock is usually thin bedded, specially in its lower portion, but massive strata, producing good quarry stone, are not uncommon. The most extensive quarrying operations in this formation are within the limits of the village of Cobleskill, but only the upper beds of the formation are exposed here. Perhaps the best exposure of the formation is along the bed of the small stream which cuts the northern face of Sunset hill at East Cobleskill. The total thickness here, according to the measurements of Professor Prosser, is 95 feet, but only something over 60 feet of this thickness is exposed in the bed of the stream. Numerous falls are caused by the heavier beds, while joint fissures everywhere traverse the rock. These fissures are frequently widened by solution, and along them the stream is in places drawn off into underground drainage. Other good exposures of the rock are on the summit of West hill, where from 20 to 30 feet of this formation remain. Though heavily forested, the ledges are well exposed, and are generally broken into huge blocks by the numerous widened fissures which traverse it. Along the road between Dann's hill and Sunset hill, ledges of the Upper Onondaga crop out abundantly. Near the northeastern end of the outcrop the rock has the characteristics of a coral reef with species of Favosites, Zaphrentis and Eridophyllum occurring in abundance. The coral reef structure is characteristic of this formation in other parts of the State, and it is most probable that in this region numerous other reefs occur, which were the source of the lime sand and mud from which these clastic limestones were made. Good exposures of this limestone are also found on the small creek which descends the east face of the depression between Sunset hill and South hill, opposite Frisby's mill and again on the slope of East mountain, where

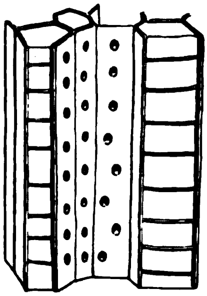


Fig. 121 Favosites basalticus

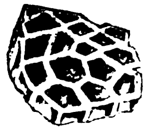


Fig. 122 Favosites basalticus

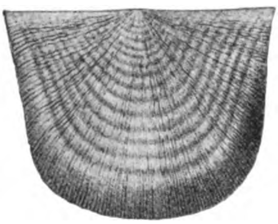


Fig. 125 Leptaena rhomboid-alis

Fig. 123 Zaphrentis prolifica

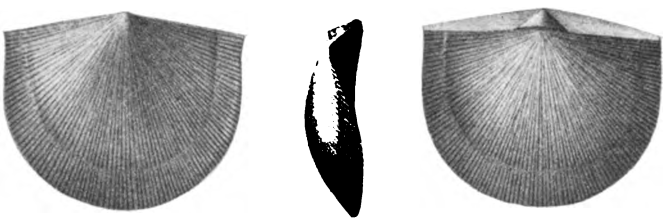


Fig. 124 Orthothetes pandora

nearly 100 feet are exposed in successively outcropping ledges above the Esopus shales. At Borst Mills, a mile above Middleburg, the Onondaga crosses the Schoharie kill, producing a low fall with ledges visible along the bank.

Fossils of the Onondaga limestone

A complete list of the Onondaga fossils found in the Schoharie region is given in chapter 7. A few of the more characteristic may be noted here. Of the corals making up the reefs, only a few are cited here and in the list, since no complete study of the coral fauna of the New York Onondaga has been made. The following are abundant: Favosites basalticus [fig. 121, 122], most readily recognized by the single, rarely double, row of large mural pores in each wall of the corallites; F. epidermatus with two or more rows of mural pores on each face of the corallite separated by faint elevated ridges; Zaphrentis prolifica [fig. 123], a short curved, hornlike species with the septa slightly twisted at the center; Cyathophyllum robustum, a large, robust, cylindric species with numerous thin septa and an abundance of dissepimental tissue. With these occur several species of Dendropora, slender, more or less cylindric and branching stems with the corallites opening in circular or oval apertures superficially far apart.

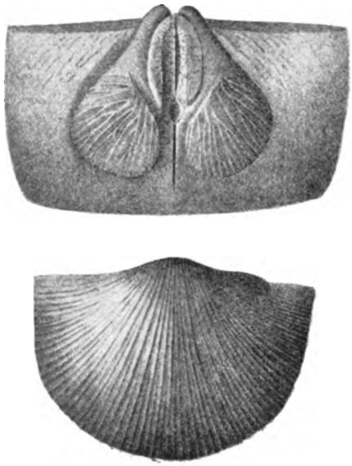


Fig. 126 Stropheodonta inequiradiata

Among the brachiopods the following may be noted: Orthothetes pandora [fig. 124], a reversed strophomenoid shell, slightly unsymmetric, with the pedicle valve moderately concave anteriorly and with radiating striae increased by intercalation and crenulated by concentric striae; Leptaena rhom-

boidalis [fig. 125]; Stropheodonta inaequiradiata [fig. 126], a very convex species with sharp striae, alternatingly coarse and fine; S. hemispherica [fig. 127], a large, robust and strongly convex species and Strophonella ampla [fig. 98], already noted in the account of the Schoharie grit fossils.

Among the Spirifers are: Spirifer duodenarius [fig. 128], recognized by its extended hinge line and broadly rounded plications, together with well marked concentric lamellose lines which are strong however in the best preserved specimens only.

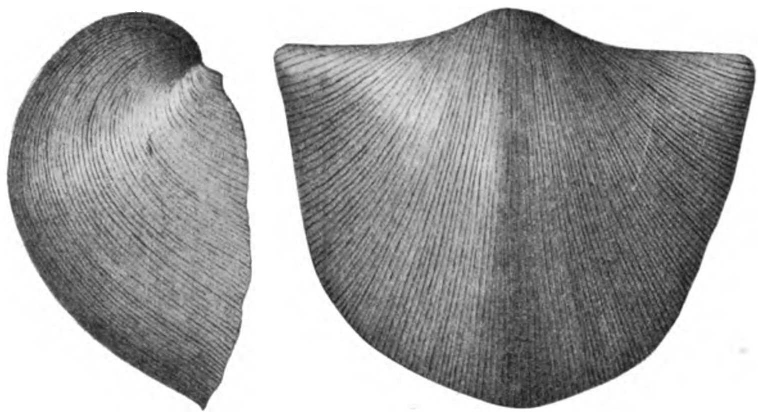


Fig. 127 Stropheodonta hemispherica

The species is also abundantly represented by molds in the Schoharie grit. Sp. acuminatus [fig. 129], one of the large and most robust species in this formation with a very prominent and sharp sinus in the pedicle and corresponding strong elevation in the brachial valve, forming a pronounced anterior deflection with plications flatly rounded and with a depression down the center; and Sp. divaricatus [fig. 130], still larger than the preceding and with the plications extending over the sinus and the indistinct fold.

Other common brachiopods in this formation are: Meristella nasuta [fig. 131], recognized by its subquadrangular outline, strongly incurved beak of pedicle valve and pronounced anterior nasute extension; Pentagonia unisulcata

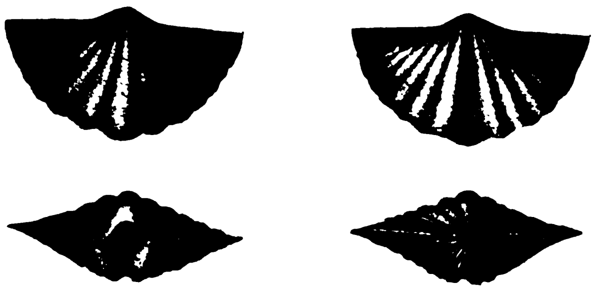


Fig. 128 Spirifer duodenarius

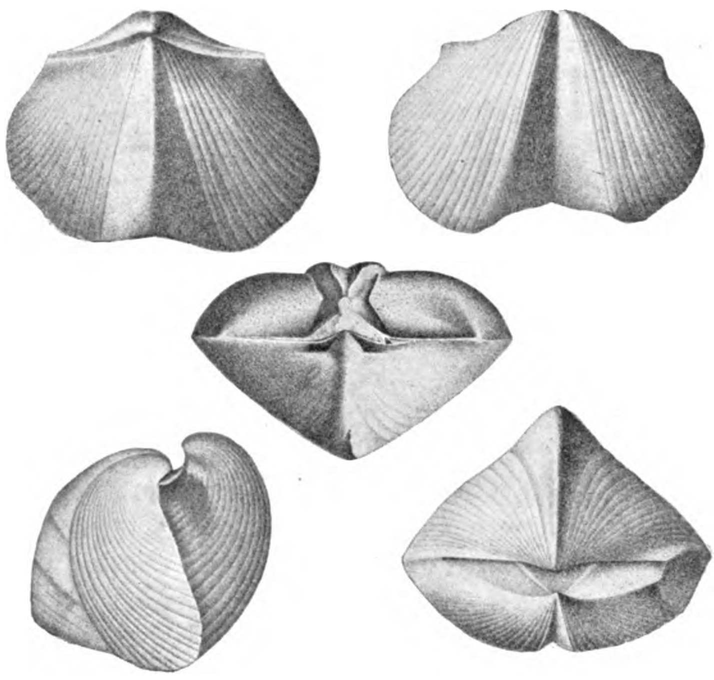


Fig. 129 Spirifer acuminatus

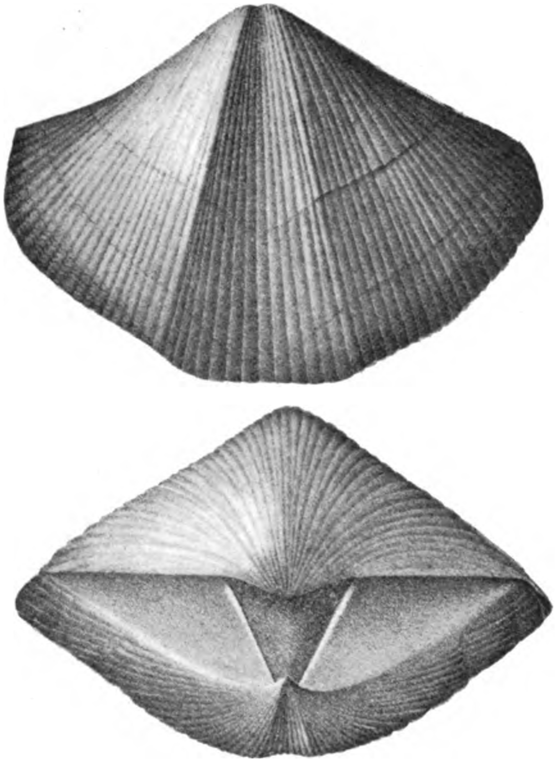


Fig. 130 Spirifer divaricatus

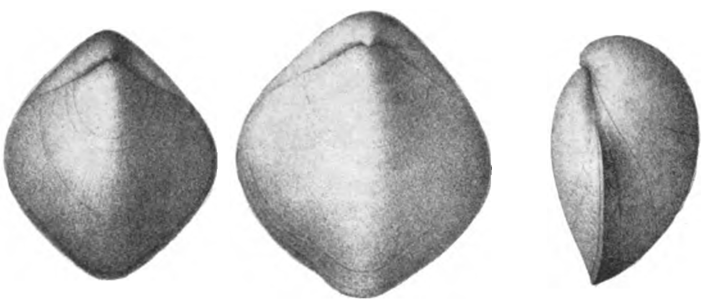


Fig. 131 Meristella nasuta

[fig. 132], easily recognized by its peculiar form; Atrypa reticularis [fig. 133], generally quite robust; and Pentamerella arata [fig. 100], a pentameroid shell with strongly arching beak as in Gypidula, but with sinus in the pedicle valve and corresponding fold in the brachial valve, though these are not always pronounced. Strong bifurcating rounded plications cover all except the upper part of the beak. Finally among the more common species should be named Amphigenia elongata [fig. 134], which when full grown is a large, terebratuloid shell not unlike Rensselaeria but proportionally wider. The internal characters are pentameroid and the surface is covered with fine radiating striae.

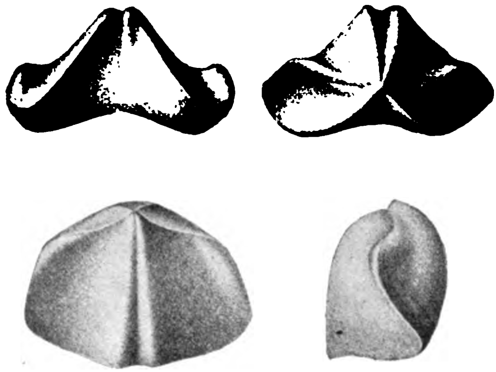


Fig. 132 Pentagonia unisulcata

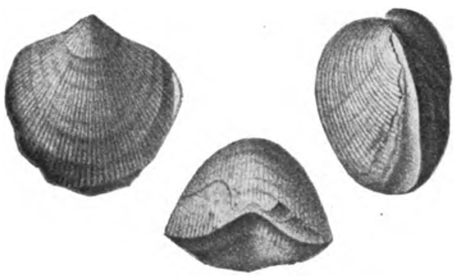


Fig. 133 Atrypa reticularis

Among the gastropods the following are common and characteristic: Platyceras dumosum [fig. 135], an extremely spinose shell, with the apex enrolled. The form varies from subcylindric in the adult to extremely ventricose. Diaphorostoma lineatum [fig. 136], a close coiled, nonumbilicate, low-spired shell, with uniformly enlarging suborbicular aperture, and fine spiral striae cancellated by the lines of growth. Euomphalus decewi [fig. 137], a flat coiled shell with the whorls enrolled in nearly the same plane and barely touching, and with a strong carina on the upper part of the last whorl,

marking a marginal slit or notch; surface with fine lines of growth; and Phanerotinus laxus [fig. 138], a very loose coiled shell with widely separated whorls gradually enlarging toward the subcircular aperture and coiling nearly in the same plane.

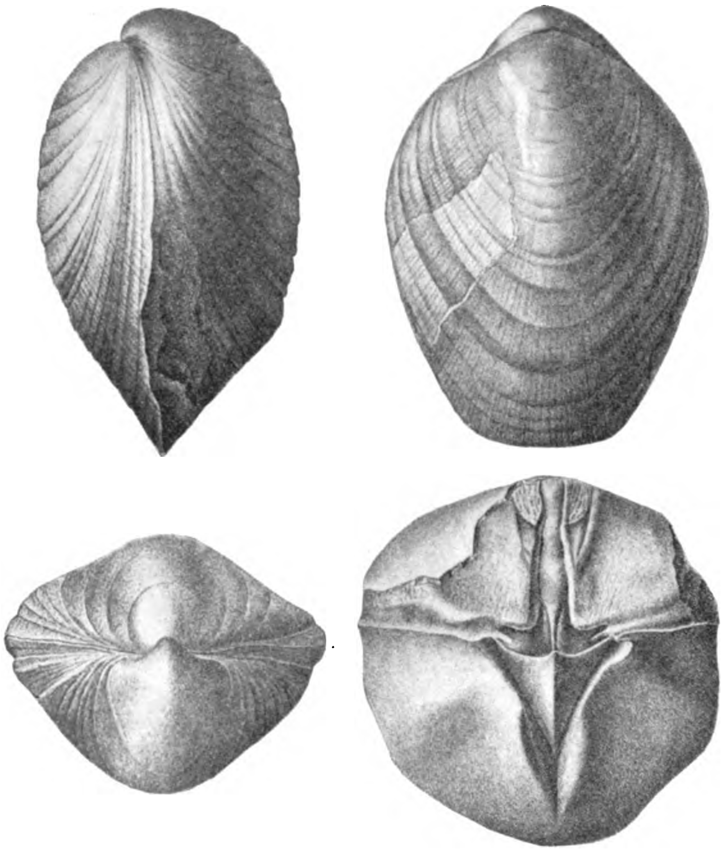


Fig. 134 Amphigenia elongata

The pteropods are represented by Tentaculites scalariformis [fig. 139], a strongly and regularly annulated, elongated cone, with the subequal interspaces marked by fine, even, transverse striae.

Among the cephalopods occur: Cyrtoceras eugenium [fig. 113], already described under the Schoharie grit; Gyro-

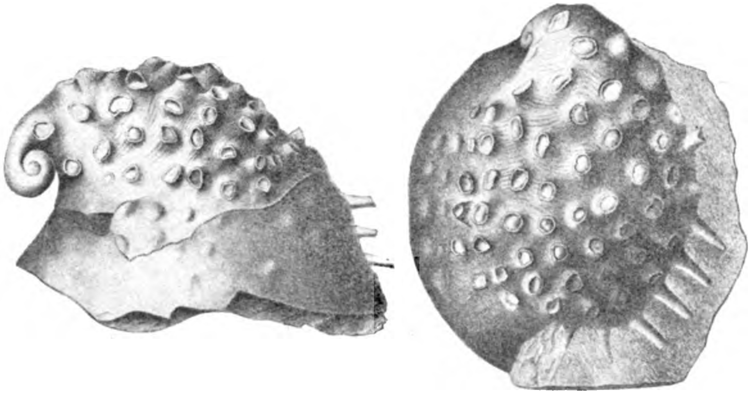


Fig. 135 Platyceras dumosum

Fig. 136 Diaphorostoma lineatum

Fig. 137 Euomphalus decewi

Fig. 138 Phanerotinus laxus

Fig. 139 Tentaculites scalariformis

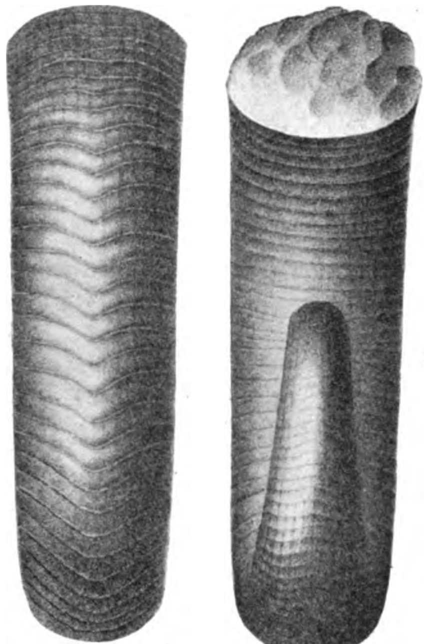


Fig. 140 Gyroceras trivolve (dorsal and ventral views)

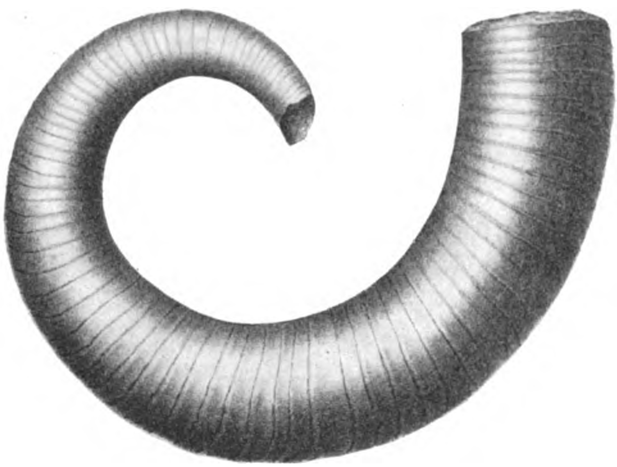


Fig. 141 Gyroceras trivolve (side view)

Fig. 142 Gyroceras matheri (reduced)

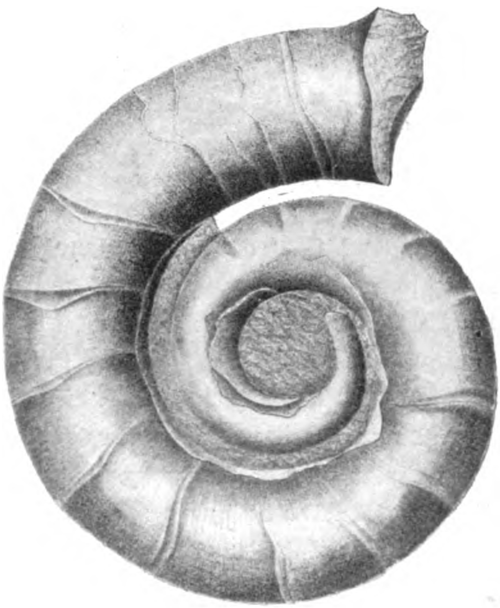


Fig. 143 Gyroceras undulatum

ceras trivolve [fig. 140, 141], similar to the preceding but more strongly coiled, with similar surface markings, evidently the direct successor of the first species; G. matheri [fig. 142], like G. trivolve, but with more prominent, distant, irregular, concentric ridges, which are extended about 10 mm beyond the shell, and a symmetric cross section; G. undulatum [fig. 143], a closer coiled species than the preceding, with strong,

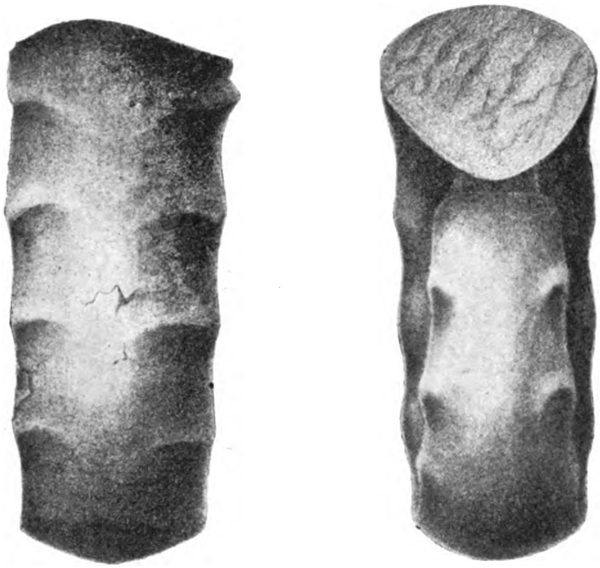


Fig. 144 Gyroceras paucinodum

distant undulations; and G. paucinodum [fig. 144], like G. undulatum, but with the undulations replaced by nodes along the lateral margins of the coil.

The trilobites are represented by Dalmanites (Odontocephalus) selenurus [fig. 145], of which the pygidia are most common, and readily recognized by the double prongs of the base, while the cephalon may be known by the anterior crest and the form of the glabella; D. calypso [fig. 146], easily identified by the form of the glabella, short cheek spines, crescentic eyes, and large pygidium rounded at the base, and with an axial row of flattened spines; Lichas (Conolichas) eriopis

Fig. 145 Dalmanites (Odontocephalus) selenurus

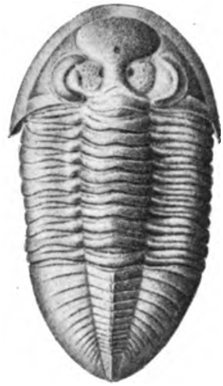


Fig. 146 Dalmanites calypso

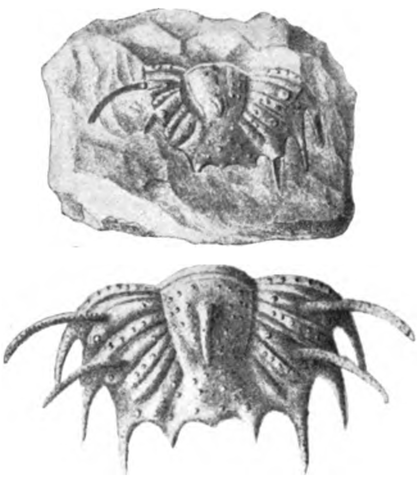


Fig. 147 Lichas (Conolichas) eriopis

Fig. 148 Proetus foliceps

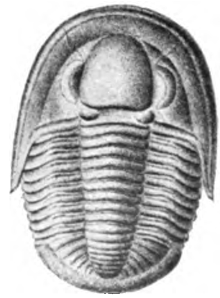


Fig. 149 Proetus clarus

[fig. 147], marked by the strongly trilobed and pustulose central portion of the head and a strongly spinose pygidium; P r o e t u s f o l l i c e p s [fig. 148] and P. c l a r u s [fig. 149], the former distinguished by its rounded cardinal angles, tumid, faintly furrowed glabella and rounded pygidium without marginal fold; the latter by long cardinal angles, glabella without lobes, and short crescentic pygidium with marginal fold.

Marcellus shale

In all the hills bounding the Schoharie valley between Schoharie and Middleburg, with the exception of West hill, the Onondaga limestone is succeeded by about 180 feet of black, fissile shales, which split up into thin leaves and become more or less rusty on exposure. These are the Marcellus shales, which represent the mud deposits succeeding the coral reefs of the Onondaga period. They are not extensively exposed in this region, for on all the hillsides they have weathered so much that the outcrops are covered with soil. They form the gentler slopes above the limestone terrace, and are surmounted by the steeper slopes of the arenaceous Hamilton beds overlying them.

One of the few accessible localities where the Marcellus shales can be examined is on the eastern base of South hill, northwest of Middleburg. North of the farm of Mr Henry V. Pindar and between it and a point opposite Borst Mills (at which locality the top of the Onondaga forms the river bed) several exposures occur in the bottoms of small streamlets which incise the slope of the hill. Some of the beds are exposed along the road, where it descends to the flats of the river. The highest beds are best shown about a quarter of a mile north of Mr Pindar's house, where an unsuccessful attempt has been made to mine the upper layers for coal [map: VIII i, 87]. This locality is best approached by a path which branches from the road where this has reached the level of the flats. At the "coal mine" the shale is very black and carbonaceous, the upper four feet having suffered some crushing and internal shearing owing to the pressure of the overlying rock and the yielding character of these car-

bonaceous beds. This sliding has resulted in the production of numerous sliding planes or "slickensides" which show by parallel striations the direction of movement. The mass has thus assumed the superficial aspect of coal, which has led to the exploitation of these beds. The slickensided layers are succeeded by heavy bedded, arenaceous strata, chiefly limestones, which belong to the Hamilton beds. Fossils here are mostly rare, but the little pteropod, Styliolina fissurella and some small brachiopods are not infrequently met with in the black shales.

The upper beds of the Marcellus formation are seen along the northern slope of Sunset hill above the road which crosses the col connecting that hill with Dann's hill. The outcrops are mainly found on the edge of the woods, though occasionally in the fields. Dark, often rusty, fissile shales, containing Styliolina fissurella in abundance, are seen below the sandstones of the Hamilton group. Not far below the top of the formation are some thin limestone layers, which are almost wholly composed of two minute brachiopod shells, Liorhynchus mysia and Strophalosia truncata, the former predominating. With these occur rarely Liorhynchus limitaris. These same beds are again seen in the slope of East hill, southeast of Schoharie, where the surface for 50 to 60 feet above the Onondaga is covered with blocks of this limestone, which is also largely used in the construction of stone fences. The shales with Styliolina continue to about 75 or 80 feet above the road, and are capped by the Hamilton sandstones. Prosser reports 15 feet of black argillaceous shales in the bank of Mill creek on the north end of Vroman's Nose. These shales contain Chonetes mucronatus? [fig. 150], Styliolina fissurella [fig. 153], Orthoceras subulatum?, and crinoid segments. The locality is over a mile above Borst's dam where the base of the Marcellus stands at the level of the river. With a dip of about 135 feet to the mile, the base of the Marcellus would be carried more than that depth below the river level. Furthermore as the outcrop is from 75 to 80 feet above the

river level, this would make the total thickness of the Marcellus something over 225 feet, which is greater than that found in other sections. It is possible that the dip here is less than in other portions of the valley. A good exposure of the Marcellus beds is found in the bed and banks of Stony brook[1] southeast of Schoharie.

At the "Three Corners" just above the 1000 foot contour line, on the road leading up the hill along the banks of the brook, is a cascade over the upper beds of the Onondaga limestone. About 50 yards above the bridge near the confluence of the two branches occurs an outcrop of "about 20 inches of dark gray, impure limestone with Orthoceras marcellense [fig. 154] and other fossils which usually accompany Agoniatites expansus, though that species has not been observed".[2] This is the eastern extension of the Goniatite (Agoniatite) limestone, which is a characteristic member of the Marcellus formation in central New York. The elevation of this bed above the top of the Onondaga is at the most 30 feet.

For 16 feet above this the section is covered, then follows a continuous exposure of Marcellus shale for nearly a mile, to Borst's sawmill, which is 180 feet above the limestone. The upper beds in this section, though retaining their dark blue gray or blackish color, carry Spirifer and Chonetes and in this respect suggest correspondence with the upper beds in western sections which have latterly been regarded as pertaining to the Marcellus.

Typical Hamilton sandy shales are exposed just above Borst's mill. No limestone beds were observed in the section above the basal limestone . . . The evidence in this section clearly indicates the rapid extinction of the Agoniatites limestone eastward from Otsego county and at points east of that here mentioned no outcrops of the horizon or evidence of its index fossils have been recorded.[3]

Other exposures of the Agoniatite limestone are found on the Lamoreaux farm, one mile southwest of Schoharie village, and on the Burton farm, one mile still farther south. "At these places

[1]Not Stony creek, which is east of Middleburg. This more northern stream occupies the depression between East hill and Hartman's hill.

[2]Clarke, J. M. N. Y. State Mus. Bul. 49, p. 123.

Clarke. *Loc. cit.* p. 123–24.

the limestone lies just below the surface and has been taken out for the construction of farm walls, but no exposure is afforded which defines the position of the beds in the rock section."[1] It is from these exposures that the fossils credited to the Goniatite limestone of Schoharie, in the *Palaeontology of New York,* were probably obtained.

Characteristic fossils of the Marcellus beds

Among the brachiopods characteristic of the shales is Chonetes mucronatus [fig. 150], recognizable by its coarse plications and spines parallel to the hinge line; Strophalosia truncata [fig. 151], readily recognized by the small size, strongly convex pedicle valve with truncated apex, and surface covered with faint spines, and slightly concave spine-covered brachial valves, occurring abundantly in the calcareous beds of this formation about Schoharie; and Liorhynchus mysia [fig. 152], a small shell readily distinguished from other species by its circular form, and few strong plications which reach half way from the margin to the beak, and occurring with the preceding species in the limestone bed in the Upper Marcellus, but generally more numerous than that species.

Fig. 150 Chonetes mucronatu

Among the pteropods, Styliolina fissurella [fig. 153] is the most prominent. It is easily recognized by the minute needlelike form, and the depressed central line in the compressed specimens on the shale.

The cephalopods are most characteristic of the Agoniatite limestone. Orthoceras marcellense [fig. 154], of slender form with excentric siphuncle and fine concentric surface striae and faint longitudinal ridges, is one of the most characteristic. With this occurs Gomphoceras oviforme [fig. 155], a small, short (breviconic) exogastric species, with large trilobate

[1] Clarke. *Loc. cit.* p. 123.

Fig. 151 Strophalosia truncata

Fig. 152 Liorhynchus mysia

Fig. 153 Styliolina fissurella

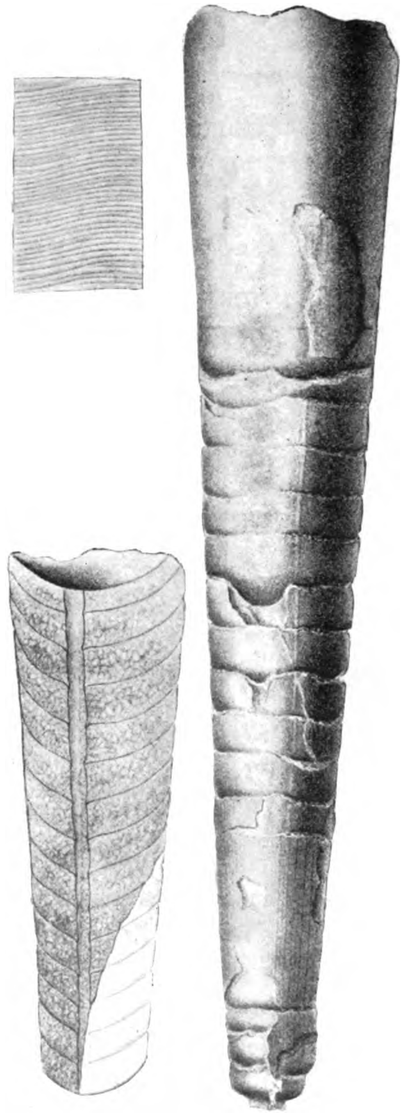


Fig. 154 Orthoceras marcellense

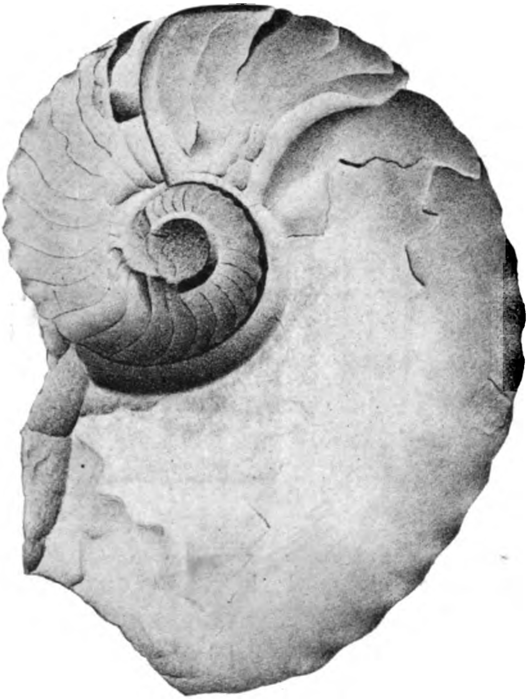


Fig. 156 Nautilus (Discites) marcellensis

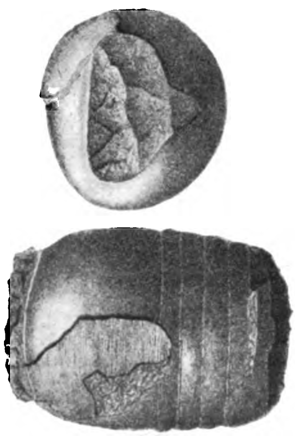


Fig. 155 Gomphoceras oviforme

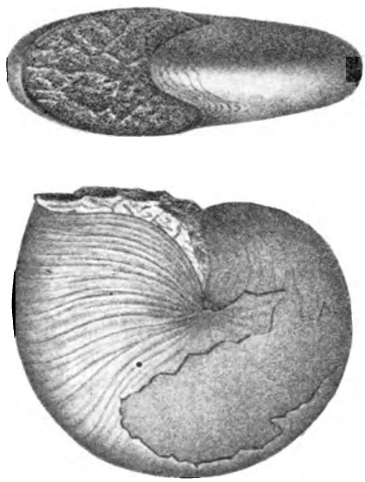


Fig. 158 Parodiceras discoideum

aperture and the surface marked by fine lines of growth and longitudinal lines, strengthened at regular intervals.

The nautiloids are represented by Nautilus (Discites) marcellensis [fig. 156], characterized by an angularity of the umbilical margin of the whorl, by a noded outer or ventrolateral margin, and by a suture having a broad lateral lobe, with angular saddles on the umbilical and ventrolateral margins, and a rounded lobe on the venter.

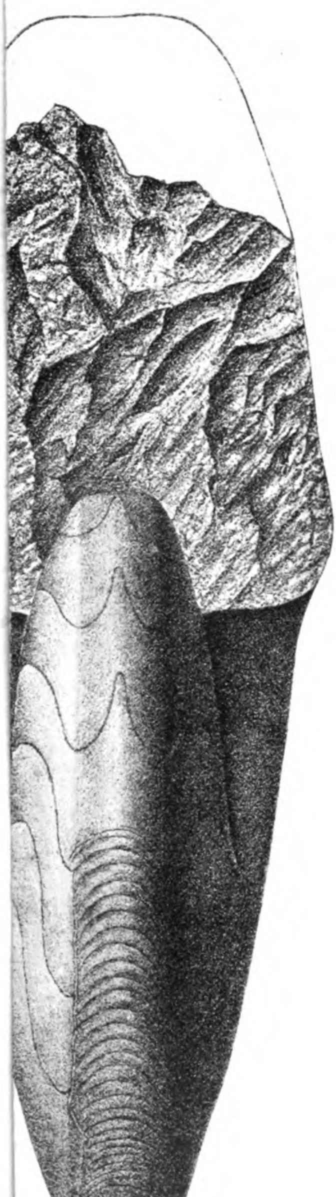
The goniatites of this limestone are represented by the large and characteristic Agoniatites expansus (Vanuxem) [fig. 157] (Goniatites vanuxemi Hall). This species when adult is a foot or more in greatest diameter, with a large living chamber, which has flattened sides and a rounded venter. In the earlier stages of development the venter is flattened and margined by ventrolateral ridges. The surface is furthermore ornamented by sinuous ridges. The suture is simple, with a narrow ventral or siphonal lobe. Parodiceras discoideum [fig. 158] is a smaller smooth species, with the umbilicus closed, owing to the close coiling of the shell. This character is shown even in the young specimens.

Hamilton shales

The Marcellus shales are succeeded by arenaceous beds, chiefly more or less impure quartz sandstones alternating with silicious clay mudrocks which often become shale. In the coarser sandstones, brachiopods not infrequently occur, chiefly as molds, Spirifer granulosus predominating. The lower beds of this series are shown in the cliff of Vroman's Nose, which rises some 600 feet above the level of the Schoharie river. The lower beds here are dark gray shales and thin sandstones, the former becoming more blocky toward the top. In the coarser beds, Spirifer granulosus is common together with the curious marking known as Spirophyton and already represented in the Esopus shales.

Another cliff of Lower Hamilton strata is seen in the southwestern portion of Hartman's hill,[1] east of Middleburg. These

[1] So named from one of the early settlements of the Palatines at the foot of this hill, which was called Hartman's Dorf.



cliffs are capped by the harder sandstones of the series and like that of Vroman's Nose, are kept vertical. Higher beds of this series are found in ascending the hill by the road leading east from Davis Crossing. Other exposures of the Hamilton shales are found in the valleys of Stony creek and the Little Schoharie, and at numerous points along the lower slopes of Moheganter hill, south of Middleburg. The total thickness of the Hamilton beds of this region is about 1500 feet[1] exclusive of the 180 feet of Marcellus. The series consists mainly of sandstones and arenaceous shales, and the fossils in these beds are generally preserved only in the form of molds. In the upper beds of the series flagging stones are not infrequently found.

Fossils of the Hamilton beds

Only a few corals have been obtained from these beds, the most common being Ceratopora intermedia (Nicholson) [fig. 159], composed of irregular cylindric branches, with a coarse cystoid structure internally.

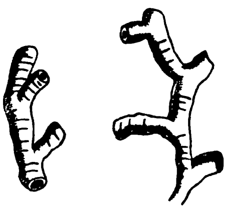


Fig. 159 Ceratopora intermedia

Among the common brachiopods are: Spirifer granulosus [fig. 160] a large robust species with moderate hinge area, broad rounded sinus, fold with median depression and surface covered with granules or fine postules; Sp. mucronatus [fig. 161] generally extremely mucronate with a faint plication in the median sinus and a depression in the fold; Chonetes coronatus [fig. 162], a large species characterized by fine radial striae, and five or six short oblique tubular spines on each side of the beak, a strong cardinal process and median septum in the brachial valve; Ch. mucronatus [fig. 150], readily recognized by its coarse, rounded plications and outward bending spines, parallel to the hinge area; Ch. deflectus [fig. 163], a convex species with numerous fine striae and abruptly outward-curving cardinal spines; Athyris

[1] Prosser figures out a thickness of 1685 feet for the Hamilton and Marcellus. N. Y. State Geol. 17th An. Rep't, p. 190.

spiriferoides [fig. 164], a large rotund smooth species with valves nearly equally convex and a median depression in the anterior portion of the pedicle valve; Cryptonella lincklaeni [fig. 165], a terebratuloid shell with strongly incurved beak, angular umbonal slopes, punctate shell structure and comparatively small and gibbous form; Tropidoleptus carinatus [fig. 166], a strophomenoid shell with coarse,

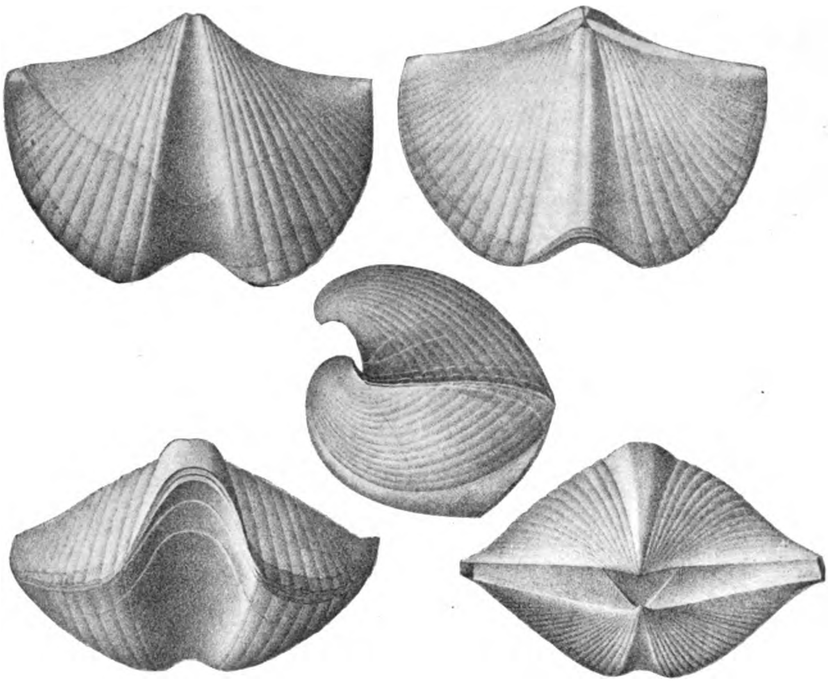


Fig. 160 Spirifer granulosus

rounded plications strongest in the center; Camarotoechia prolifica [fig. 167], a rhynchonelloid shell with slender angular plications, shallow median sinus which is gently curved upward in front, with nearly straight or slightly curved beak, and of nearly equal length and breadth in young specimens.

Among the common pelecypods are: Nucula bellistriata [fig. 168], characterized by the regular curve of the basal margin, the position of the beak, one fourth the length

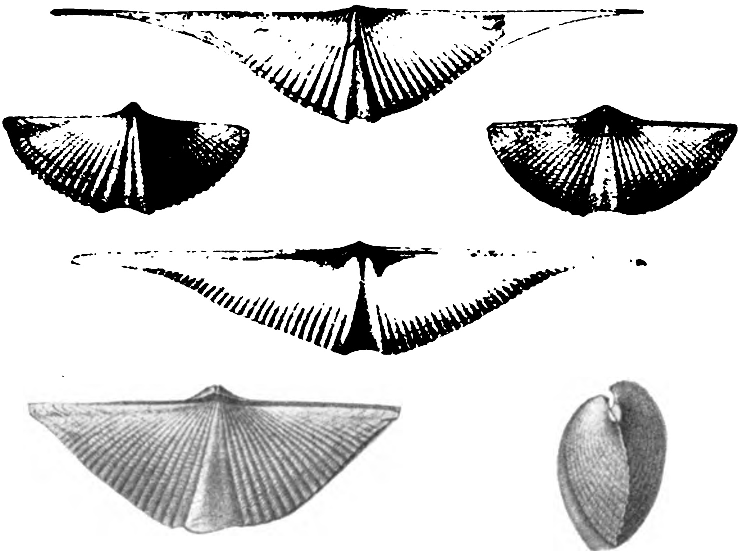


Fig. 161 Spirifer mucronatus

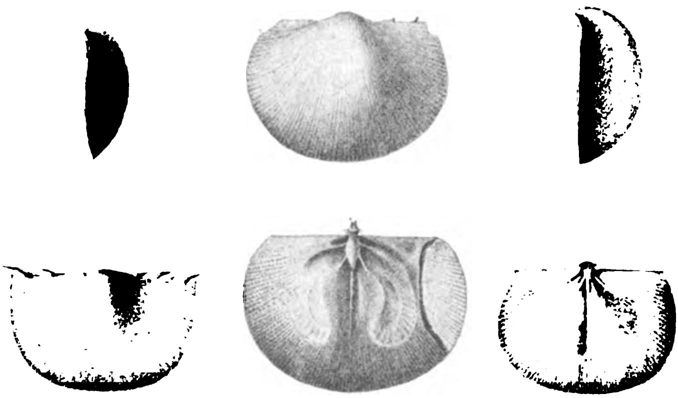


Fig. 162 Chonetes coronatus

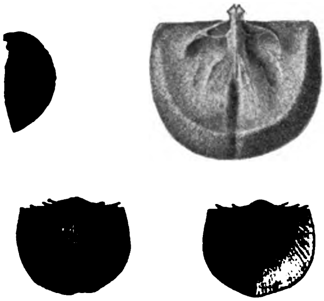


Fig. 163 Chonetes deflectus

Fig. 165 Cryptonella lincklaeni

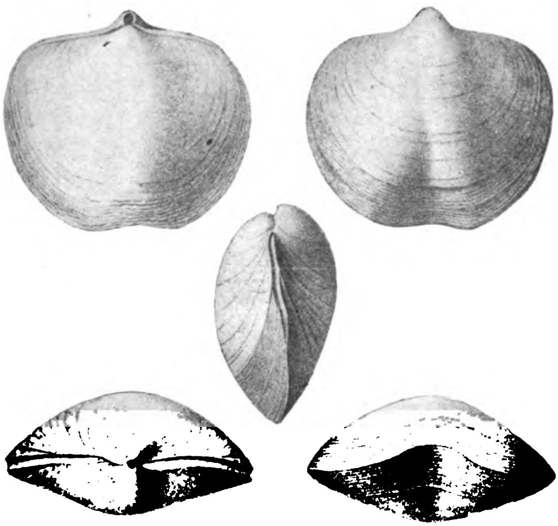


Fig. 164 Athyris spiriferoides

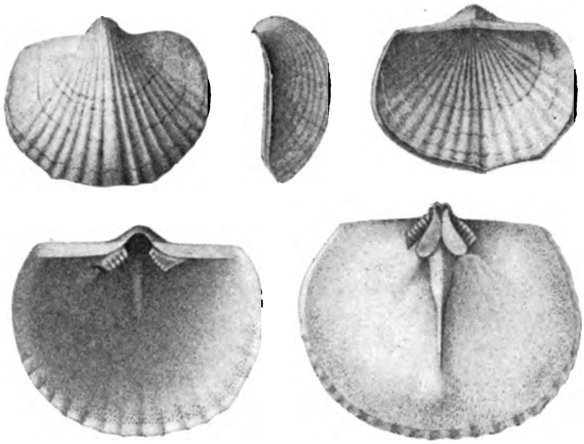


Fig. 166 Tropidoleptus carinatus

Fig. 167 Camarotoechia prolifica

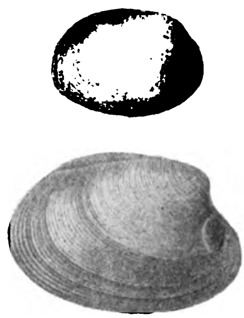


Fig. 168 Nucula bellis-triata

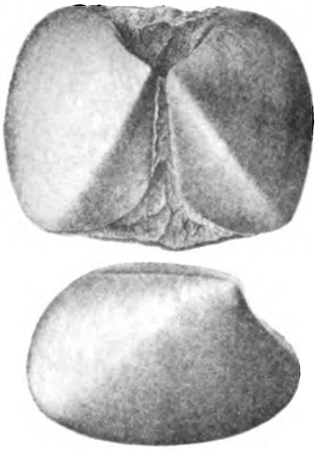


Fig. 169 Cypricardella tenuistriata

Fig. 171 Nyassa arguta

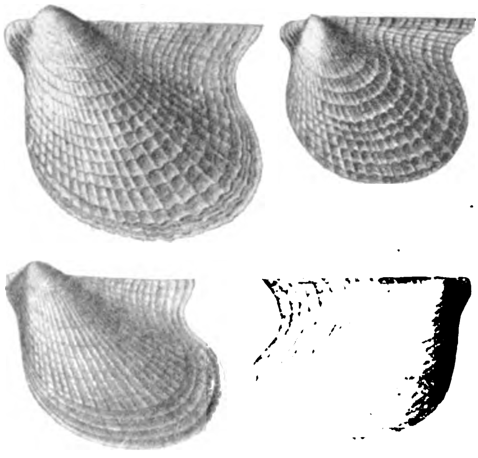


Fig. 170 Actinopteria boydi

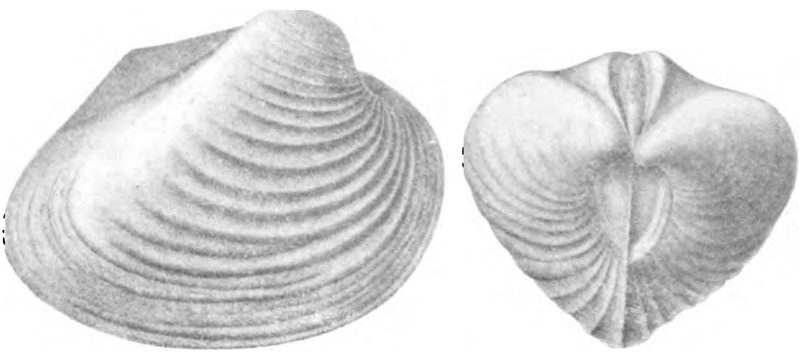


Fig. 172 Grammysia alveata

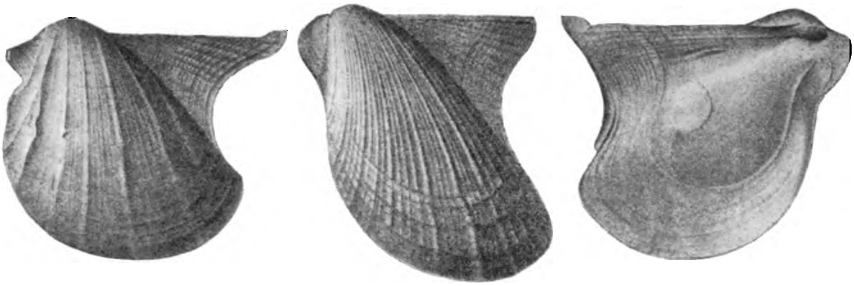


Fig. 173 Pterinea flabellum

Fig. 174 Pleurotomaria capillaria. x2

Fig. 176 Bellerophon patulus

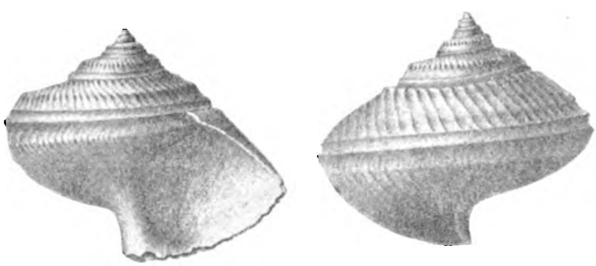


Fig. 175 Pleurotomaria subcomarginata. x2

from the margin of the shell, and fine, regular, uniform, concentric striae, together with the hinge structure characteristic of the genus; Cypricardella tenuistriata [fig. 169], a shell of subrectangular outline with a pronounced umbonal

Fig. 177 Homalonotus dekayi

Fig. 178 Phacops rana

angulation and extremely fine, tenuous, concentric striae; Actinopteria boydi [fig. 170], an oblique winged shell with the wing not strongly defined, a marked anterior ear and strong surface markings with concentric striae, which however do not interrupt the radii; Nyassa arguta [fig. 171], a modioloid shell with numerous small teeth beneath the beak, arcu-

ate cardinal line, and rounded to angular umbonal slope, anterior of which there is a faint oblique depression; Grammysia alveata [fig. 172], a large coarse shell with strongly forward-pointing beak, coarse subregular concentric folds which become obsolete on the posterior portion of the shell; Pterinea flabellum [fig. 173], an oblique shell with convex left and

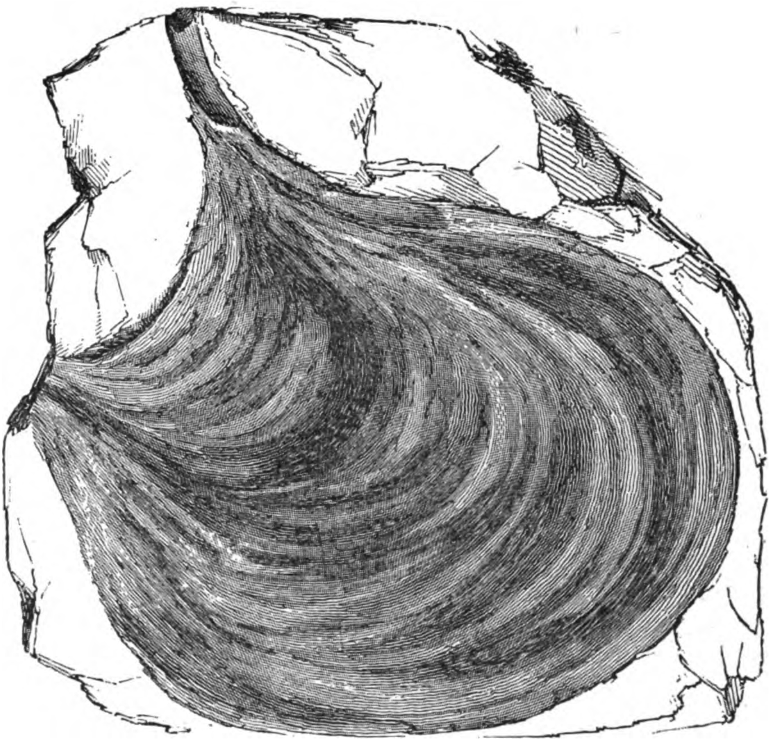


Fig. 179 Spirophyton velum

flat right valve, large and well defined wing and strong coarse radiating striae increased by repeated intercalations of finer ones.

Among the commoner gastropods are: Pleurotomaria capillaria [fig. 174], a strongly sculptured, high spired species in which the intersections of the lines of growth and the spirals are spinose; P. sulcomarginata [fig. 175], another sculptured form, in which the upper portion of the whorl is flat, so as to produce a conic spire, with the band on the outer margin

of the whorl; Bellerophon patulus [fig. 176], characterized by a broadly-flaring, nearly circular aperture and a faint median deflection of the lines of growth.

The trilobites are represented by Homalonotus dekayi [fig. 177], a large elongate, linguiform species, with faintly marked pygidium, rectangular glabella, subtriangular cephalon, and thorax scarcely trilobate; Phacops rana [fig. 178], characterized by the broad subpentagonal, strongly pustulose glabella, prominent eyes, and nearly semicircular pygidium.

The problematical marking, Spirophyton velum [fig. 179], which differs from the species in the Esopus chiefly by its smaller size, is also common in the sandy layers of the Hamilton.

Sherburne formation

The Hamilton sandstones grade upward into a series of bluish sandstones and greenish shales which constitute the Sherburne formation of Vanuxem. West of Schoharie county, from the Chenango valley to the meridian of Cayuga lake, where this formation passes horizontally into the Naples shales of the Portage, it is separated from the Hamilton beds by the Tully limestone and the Genesee shales. In eastern New York these formations are absent as lithic units, and the Sherburne directly succeeds the Hamilton. Its thickness is 250 feet or over, and its fossils when not merely plant remains, constitute together with those of the succeeding Ithaca beds a modified Hamilton fauna, which gradually disappears westward. In Greene and Ulster counties, this formation is unfossiliferous with the exception of scattered plant remains and probably includes the horizon of the "North river bluestone."

The most accessible locality for the examination of this rock is in the upper slopes of Moheganter hill as described in the sections in chapter 5.

In the Schoharie river valley region the line of separation between the Hamilton and Sherburne formations is not as clearly shown for part of the distance as it generally is farther west. This is due largely to the heavy mantle of drift covering the

slopes of part of the hills, also the valley near North Blenheim, where the characters of the two formations blend.[1]

The Ithaca formation

The Sherburne flags are succeeded by a series of shales and sandstones averaging 500 feet in thickness. These constitute the Ithaca formation, the age of which in this section is middle Portage. It contains a modified Hamilton fauna, which in some sections made its first appearance in the Sherburne. Tropidoleptus carinatus is often abundant, as is also Spirifer mucronatus. Other characteristic fossils are Spirifer mesastrialis [fig. 180], characterized by radiating striae on the rounded fold and sinus as well as on the flattened plications of the rather large valves; Orthonota undulata [fig. 181], a pelecypod shell of elongate form, with long and straight hinge line parallel to the basal margin, and with strong undulations or wrinkles in the posterior portion, which is delineated by a pronounced umbonal ridge; Sphenotus truncatus [fig. 182], a small elongated pelecypod with angular umbonal ridge, truncated posterior end, and fine surface striae, and Sph. cuneatus [fig. 183], a larger species with more pointed anterior and more rounded posterior end, and an additional pronounced ridge above the umbonal one. With these are other but rarer species as given in the list in chapter 7.

This formation, like the Sherburne, passes westward into the Naples beds, this change being effected beyond the meridian of Cayuga lake. In this western region the Ithaca fauna extends also much higher up, occupying most of the remaining Portage beds.

East of Schoharie county the typical Ithaca conditions disappeared earlier, and along the eastern front of the Helderbergs the Oneonta beds rest directly on the Sherburne if not on the upper Hamilton. Thus the lower Oneonta beds of the east are the equivalents in time of the Ithaca beds of the Schoharie region and farther west, while the higher Oneonta beds replace the upper

[1] Prosser, *loc. cit*, p.205. *See also* map accompanying Prosser's article.

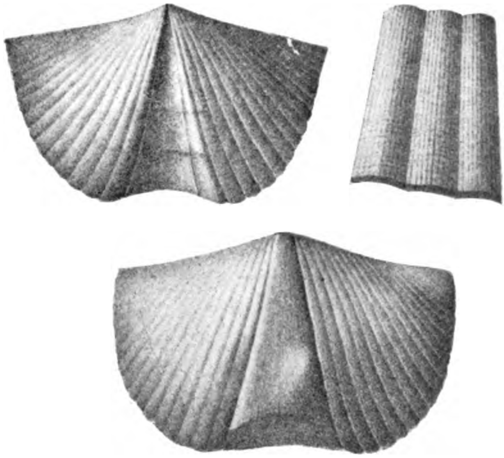


Fig. 180 Spirifer mesastrialis

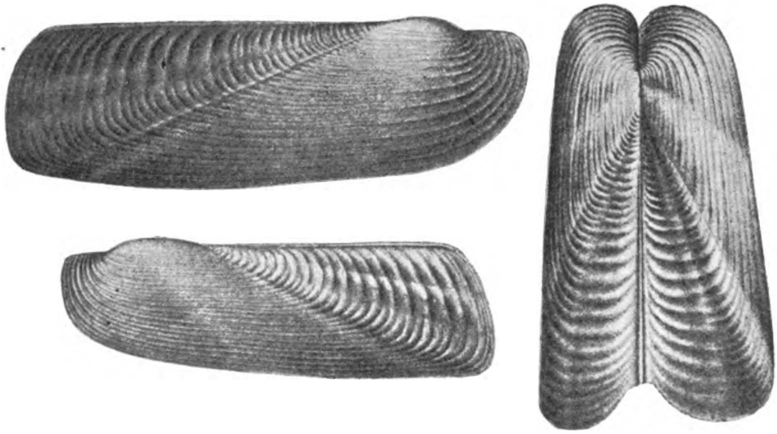


Fig. 181 Orthonota undulata

Fig. 182 Sphenotus truncatus

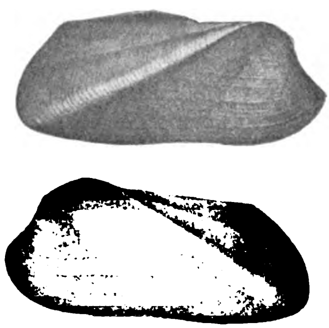
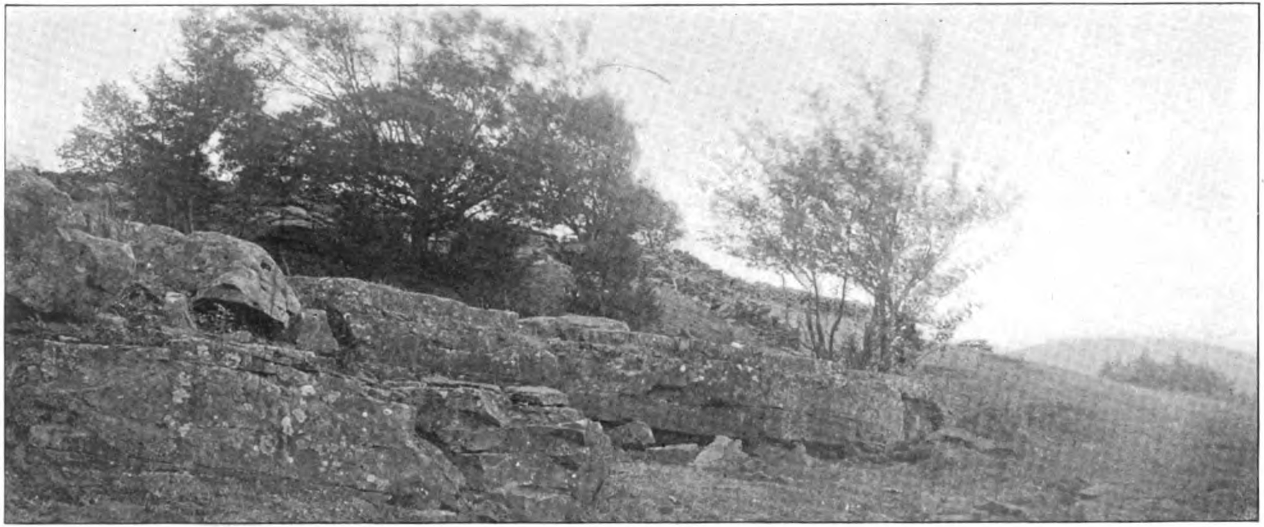


Fig. 183 Sphenotus cuneatus

Plate 15



Base of Oneonta sandstone south of Jefferson (after Prosser)

Ithaca beds in the Schoharie region, this replacement however not extending beyond central New York.

In Blenheim township about 500 feet of this formation has been noted by Prosser, but northeast from this in Moheganter hill, the Ithaca is scarcely represented, the Oneonta beds following almost immediately on the Sherburne. This shows that the source of the nonmarine sediments was to the northeast.

The Oneonta beds

From the Chenango valley eastward the Ithaca is capped by the Oneonta formation which is composed of red and green shales, reddish sandstones and coarse grained grayish to greenish gray sandstones. These rocks are nearly unfossiliferous, containing

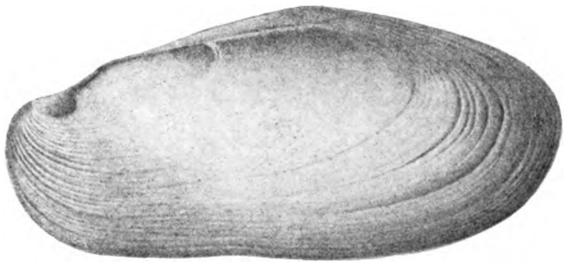


Fig. 184 Archanodon catskillensis

only an occasional specimen of Archaeopteris and Archanodon catskillensis (Van.) [fig. 184]. The formation has a thickness of 550 feet in the Chenango valley, and as the physical conditions under which the Oneonta was deposited appeared earlier to the eastward it gradually thickens in that direction, till in Albany and Greene counties it completely replaces the Ithaca formation.[1]

The fern Archaeopteris jacksoni [fig. 185] may be recognized by its bipinnate frond and obovate pinnules, which narrow toward and are decurrent at the base. The mussel Archanodon catskillensis [fig. 184] is elongated and not unlike Anodonta of the present time. Clarke has shown its significance as an indicator of fresh or brackish conditions.[2]

[1] Prosser. *loc. cit.* p.313–14.

[2] Clarke, J. M. N. Y. State Mus. Bul. 49, p. 199–203.

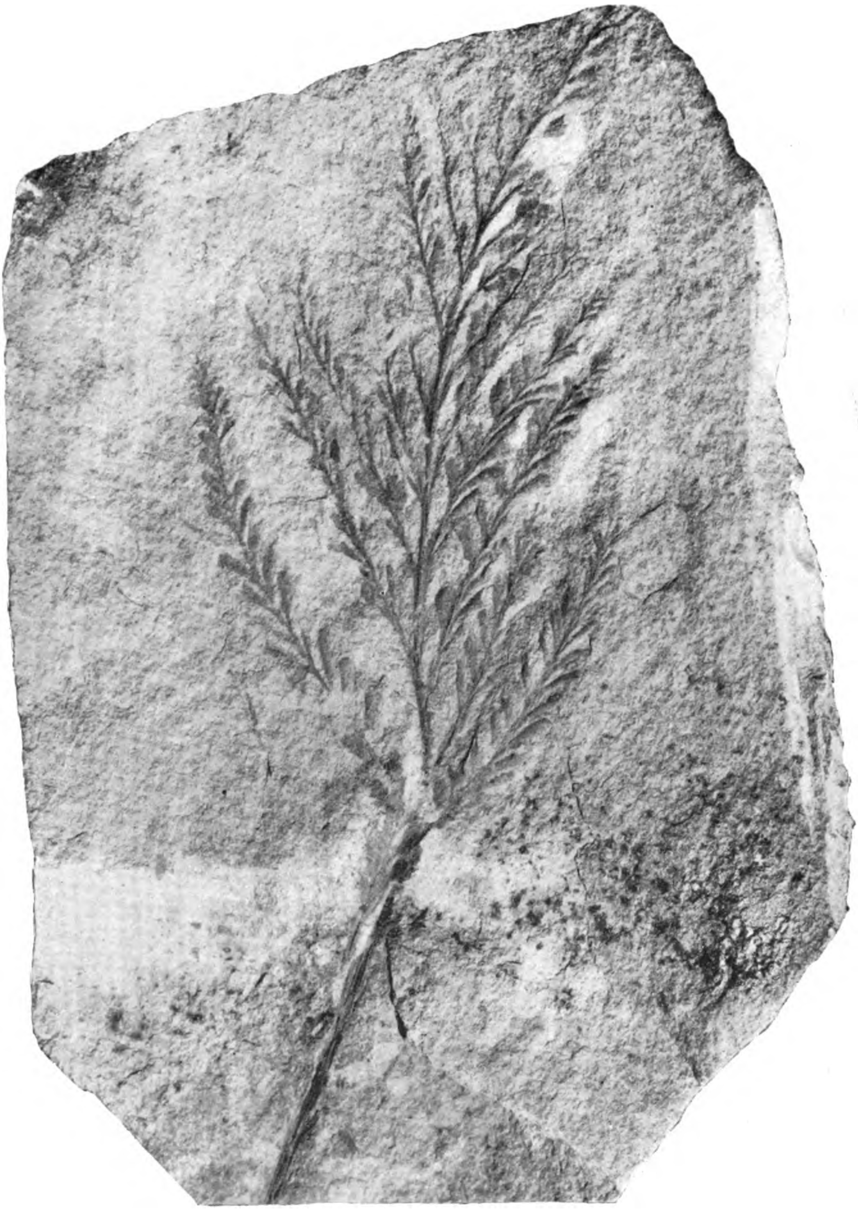


Fig. 185 Archaeopteris jacksoni Dawson. Oneonta sandstone, Otego N. Y.

In Moheganter hill the red shales and sandstones of the Oneonta make their appearance between 1200 and 1300 feet above the level of the Schoharie river. The most easily reached outcrops of these beds are on the bare knoll which rises to a height of about 2000 feet above sea level behind the house of Mr John Vroman on the road leading up Moheganter hill from the schoolhouse of district no. 11, 3 miles southwest of Middleburg.

Catskill series

This formation succeeds to the Oneonta beds in the eastern Helderbergs and the Catskill mountains. It represents the time interval during which the marine Chemung strata were deposited in western New York and elsewhere. Like the Oneonta, it is a nonmarine or estuarine formation and consists chiefly of red rock. No representatives are found in the region bordering the lower Schoharie, but in the upper gorges of that stream, and its tributaries, good exposures of these rocks are found. Their general character is indicated in the section from the Catskills to Middleburg, given in chapter 5.

Sequence of events during Middle and Upper Devonic time

As shown in the preceding chapter, the marine invasion of Oriskany time reached Ontario towards the end of that period, when the Decewville beds were deposited, embedding their commingled Oriskanian and Onondagan types. The depositional equivalent of these beds in the eastern region appears to be found in the Esopus shales.

The character of this formation is such as to indicate unfavorable conditions for the existence of the Decewville fauna in the eastern region, and it was not till the end of this period that this fauna could invade the eastern region and become that of the Schoharie grit. A comparison of the two faunas, i. e. the Schoharie and the Decewville, brings out this probable relationship.[1]

The origin of the Onondaga fauna is a question of considerable interest. That it was not derived from the Helderbergian nor

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[1] *See* ch. 7, p. 325.

the eastern Oriskany, is apparent on comparison of the faunas of the several beds. While the New York Oriskany and the Helderbergian faunas are intimately related, the Onondaga fauna with its wealth of corals appears to be quite distinct. From comparative tables published by Weller, it appears that in the brachiopod element alone, the two faunas appear to be related, while the most conspicuous differences are in the coral and mollusk elements. These latter characteristics of the fauna led Weller to say: "Both in its coral element and in its cephalopod element, as well as in the remaining mollusks, there is a strong suggestion in the Corniferous [Onondaga] of a recurrence, with profound modifications to be sure, of the more ancient Niagaran fauna, which had occupied the same province at an earlier period."[1] He further thinks that "it is altogether probable that the Corniferous [Onondaga] fauna was in large part truly an evolution product from the Niagaran, after that fauna had withdrawn from the interior and had become isolated in some province upon the border of the continent after the close of Silurian time".[2]

The new faunal element thus introduced first makes its appearance during late Oriskany (Decewville) time in the northwestern part of the Onondaga sea. During this time, as we have seen, the Esopus muds were deposited over all the eastern region, representatives having been found as far north as Lake Memphremagog.[3] Thus the Oriskany fauna became extinct in the eastern portion of the interior Mediterranean sea, but continued in the northwestern region where many of the old species became modified.

During this period there occurred the invasion of the new or Onondaga fauna, which first became mingled with the surviving Oriskanian species to constitute the Decewville fauna. Where this fauna came from is an unsettled point. Weller holds that its source was in the Arctic regions, but Schuchert thinks the

[1] Jour. Geol. 1902. 10:425–27.
[2] *Loc. cit.* p. 428.
[3] Ami, quoted by Schuchert. Am. Geol. 1903. 32:151.

evidence points to an invasion from the south, through the "Indiana basin". [*See* map, fig. 186].

Clarke says in regard to this fauna:[1]

The east presents in the arenaceous beds of the Cauda galli [Esopus] and Schoharie grit a facies which is not elsewhere seen. In clastic character, there is excellent reason for associating

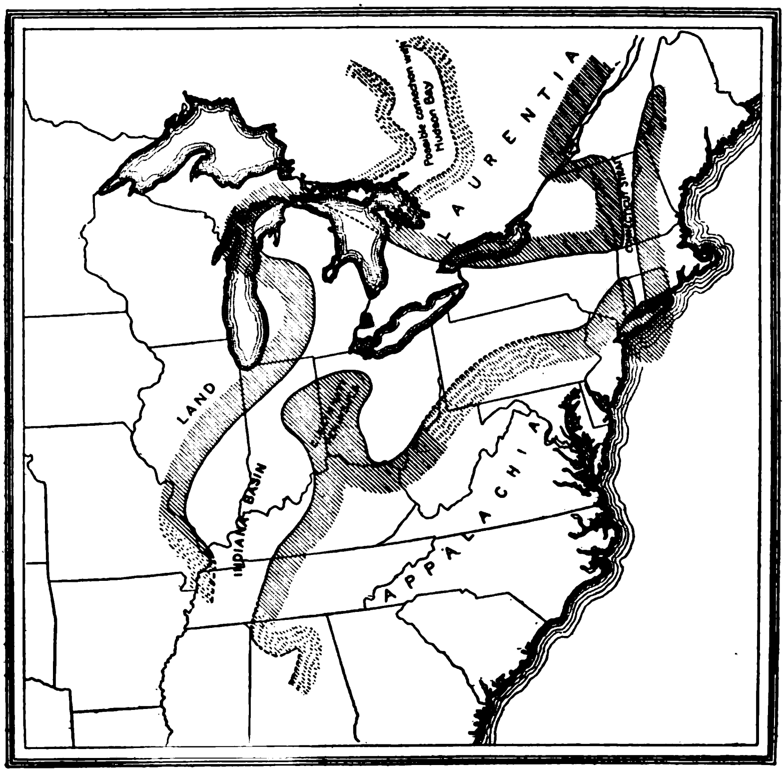

Fig. 186 Paleogeographic map of Onondaga time. (After Schuchert)

these beds directly with the deposition of Oriskany sediments as a closing stage thereof, and indeed several elements of the striking Schoharie fauna indicate derived relations to the Oriskany. This might be predicated of the trilobites specially, of the brachiopods and lamellibranchs in part, but not of the most conspicuous element of the fauna, the cephalopods. For the origin of the latter we have yet to search; they may have entered New York from the west with the fauna of the limestone and

[1] N. Y. State Mus. Bul. 52. 1902. p. 667.

have wandered into the shallow waters where Schoharie sediment was depositing; they may have, on the other hand, come in from some source, northeast or southeast, as yet unknown to us, and hence be related ancestrally to similar forms of the overlying Onondaga limestone. Present evidence seems to favor the former conclusion without disparagement to the genetic relations of these cephalopods to those of the Onondaga. It seems justifiable however to assert that the fauna of the Onondaga period as a whole, with its noteworthy coral, trilobite, cephalopod and gastropod facies unequally developed locally, is a complex congeries, largely from the western reaches of the Appalachian gulf, but freely inoculated with elements genetically from the northeast. The latter may have come in directly, geographically and genetically, through the Oriskany province of eastern New York or indirectly into the western limestones, after migration from New York southward to the end of the barrier and thence into the heart of the gulf. The latter seems specially probable of the gastropod element.

As the eastern waters cleared, the new fauna could migrate eastward and so become the Schoharie fauna. At this time a channel which extended northward along what is now the Connecticut valley and thence by way of the St Lawrence to the North Atlantic formed an outlet for the Onondaga sea to the northeast. Since black mud strata were deposited in this channel till Schoharie time, no migration of pure water species from the Atlantic could take place till just before the beginning of Onondaga time. But with this channel open, Eurasian types which had migrated along the shore of "Atlantis", a North Atlantic continent, could enter the Mississippian sea of eastern North America. Schuchert believes that a portion of the Onondaga fauna at least came into the interior sea by this channel, while another portion came from the Brazilian region by way of the southern or Indiana channel. It seems not unlikely that the cephalopod element of the Schoharie entered the Appalachian gulf from the northeast by the Connecticut channel, and migrated westward, appearing either as the same species or in modified form in the Onondaga of the western region. The same thing appears to be true of the trilobites, though some as Calymmene platys appear earlier or at the same time in

the western district, i. e. in the Decewville beds. The brachiopods on the other hand seem to have appeared first in the Decewville beds of the western area and migrated eastward, reaching the Schoharie region in Schoharie time.[1]

Toward the end of Onondaga time came the invasion of the black muds which produced the Marcellus beds and with these the diminutive fauna characteristic of these beds. Clarke holds that the Marcellus fauna invaded this territory "from the southeast along the inner or Appalachian face of the interior sea".[2] The fauna together with the black mud sediments appeared in eastern New York before the sedimentation of the Onondaga

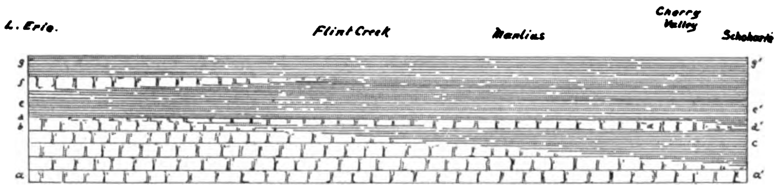

Fig. 187 Diagram showing relation of Onondaga and Marcellus beds. (After Clarke) *a*, *a'*, *b*, Onondaga limestone; *c*, lower Marcellus shale; *d*, *d'*, Agoniatite limestone; *e*, *e'*, middle Marcellus shale; *f*, Stafford limestone; *g*, *g'*, upper Marcellus shale

type was completed in western New York. In other words the lower 50 feet of the Marcellus of eastern New York is the depositional equivalent of the upper Onondaga of western New York. Near the end of Onondaga sedimentation in western New York, the eastern region over which black mud was depositing, was invaded by the last of the Onondaga species, followed directly by the "prenuncial cohorts of the Hamilton fauna".[3]

The sedimentation accompanying this invasion produced the Agoniatite limestones of the Marcellus, which in the western part of the State is a direct successor of the upper Onondaga [fig. 187]. This goniatite fauna flourished in the east central district for a time, after which it was overwhelmed by the recurrent black mud deposits, which were again characterized by the typical Marcellus fauna. A second invasion of Hamilton types occurred

[1] The recent discovery of the Schoharie fauna in northern Michigan shows the extensive transgression of the sea at that time.

[2] Clarke, J. M. N. Y. State Mus. Bul. 49. p. 115.

[3] Clarke, *loc. cit.* p. 137.

somewhat later, producing the Stafford limestone of western New York. "This invasion, too, was unsuccessful, reaching no farther eastward than the eastern part of Ontario county".[1] The third invasion into New York of the Hamilton fauna, which had come into existence by slow modification of the Onondaga species, in the northwestern portion of the interior sea, proved

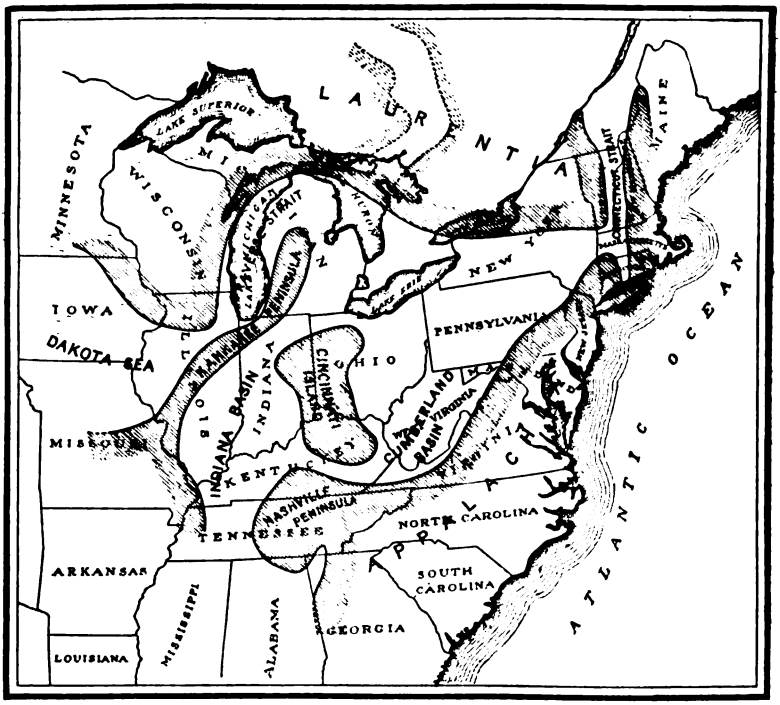

Fig. 188 Paleogeographic map of Hamilton time. (After Schuchert)

at last successful and permanent and was accompanied by the sedimentation which has given us the typical Hamilton beds. By this time the interior Palaeozoic sea had increased in size as shown on Schuchert's map [fig. 188] and a new channel across what is now eastern Wisconsin and central Illinois was opened, which connected the eastern or Mississippian sea with the Dakota sea to the west of the present Mississippi river. From

[1] Clarke, *loc. cit.*

this sea a few migrants were added to the fauna which had developed from the Onondaga fauna; other migrants continued to arrive from the seas covering South America, by way of the Indiana passage, while European arrivals continued to enter the sea through the Connecticut channel.[1] Whatever the value of the eastern channel may have been during Onondaga time, its efficiency as a transmitter of foreign invaders was greatly diminished during Hamilton time, and before the end of that period ceased entirely. This will be realized when the nature of the Hamilton sediment in the northeastern portion of the Mississippian sea is considered, for it indicates conditions which would hardly admit of the introduction of any except the most hardy shallow water types from that quarter.

At the beginning of Portage time, Laurentia, the northern continent, and Appalachia, the southeastern continent, were again united.

The apex of the Appalachian gulf during the earlier part of Portage time, must have reached to Albany, the northern shore approximately following the line of the Mohawk river and the southern shore coming in from the southwest along the inner margins of the Appalachian ridges, the two meeting in a narrow curve which gave to this inward projection of the sea but relatively slight breadth. A shoaling of the water at this end of the gulf, a differential movement raising the crust in this region, commenced when Portage time was well under way, and produced banks which must have become a more or less efficient land barrier, throwing the interior coast line well to the west, and for a while, probably for the remainder of Portage time and perhaps through all the subsequent epoch, excluded forms of marine life from these almost landlocked waters. This was the place and such the origin of the Oneonta sands. At the head of the gulf, where the waters were earliest affected by the barrier, these lie close on the very basal layers of the marine contemporaneous Portage sediments and rise ever higher in the section as they encroach southward on the gulf by the outward extension of the barriers. Having become shut off from free access to the salt water by land bars over which the sea entered only at times of stress or when the barrier was parted for a

[1] Schuchert. Am. Geol. 32:162.

while, this apical or Albany segment of the gulf was gradually purified by heavy land drainage and became a large brackish or fresh-water lagoon in which no true marine organisms could flourish [fig. 189].[1]

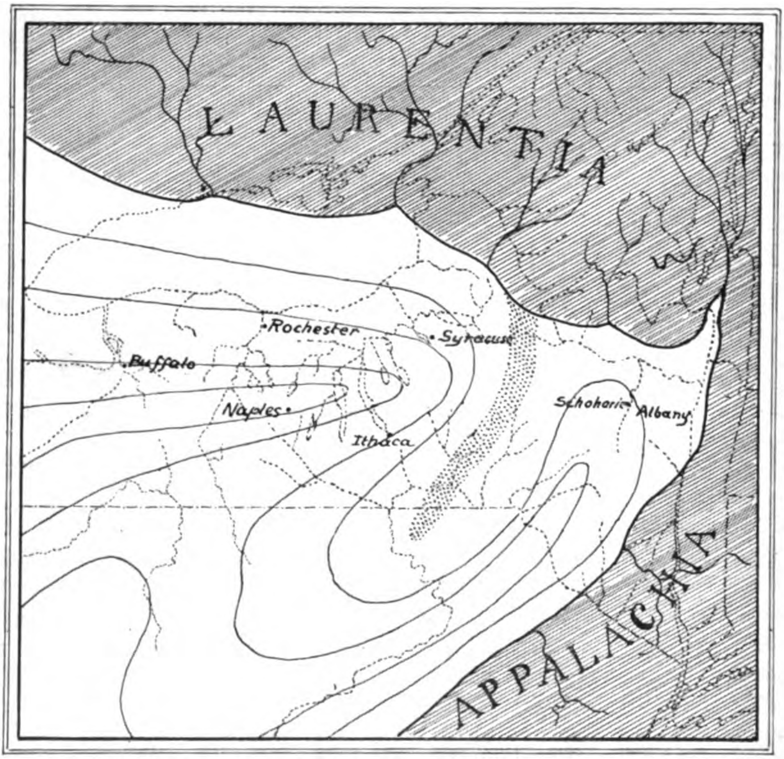

Fig. 189 Paleogeographic map of Portage time. (After Clarke)

During the early period of the Oneonta deposition in eastern New York, marine sediments enclosing a somewhat modified Hamilton fauna, were laid down in central New York. These conditions prevailed in the southwestern part of the Schoharie region and westward, forming the Ithaca beds. The fauna of these beds was at first separated by the Sherburne sand barrier

[1] Clarke, J. M. N. Y. State Mus. Mem. 6, p. 204–5. The possibility that the sediments in question are of continental origin, i. e. accumulated *above* sea level by river wash and occasional ponding, must not be overlooked. In either case, these red rocks would be the lithic equivalent of the Old Red sandstone of Great Britain.

from a new fauna arriving from Eurasia by way of a passage opened to the Pacific across the northwestern states and territories; but later it was forced into competition with that same fauna. This was the European Intumescens fauna, rich in goniatites, cardioconchs and other types.[1] The beds carrying this fauna have been named the "Naples beds" by Clarke. They are not found in the Schoharie region where the Sherburne and Ithaca beds represent them. The latter are succeeded in this region by the red sediments of the Oneonta. Going westward these covering red beds appear later and later, the beds with the Ithaca fauna continuing higher till the whole of the marine Portage is present. Marine sedimentation continued in the southwestern part of New York beyond the close of Chemung time, when the nonmarine red phase of deposition, which in the eastern region resulted in the formation of the Catskill beds, finally reached that district probably after Pocono beds had been forming for some time in the Appalachian district.

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[1] Ulrich and Schuchert have suggested that this fauna came in from the Atlantic, but the character of the sediments in the east shows that this could not have been the case, since the deposits are all of the shallow water and continental type, indicating a continuous shore line along the east and south.

Chapter 5

CHARACTERISTIC SECTIONS IN THE SCHOHARIE REGION

The following sections are given to bring out the detail of the stratigraphy of the Schoharie region.

Several of the sections have previously been published, among these the detailed section of the Hamilton and Upper Devonic strata made by Prosser. This indefatigable worker in the Paleozoic stratigraphy of eastern United States has put all students of that subject under lasting obligations by his extensive and detailed investigations of the succession of strata and the distribution of species in these regions.

Prosser's sections are freely reproduced in this chapter with such slight modifications as were desirable to bring them into harmony of arrangement with the general plan of this work[1].

1 Section of the old Brown quarry of Schoharie [2]

This abandoned quarry is in the hollow between the cemetery and the road leading east from Schoharie postoffice. The quarry wall described is just to the north of the road and wholly below it.

Near the Brown quarry, ¼ mile southeast of the Schoharie postoffice, the Salina (Brayman) shales are exposed by the roadside. In the quarry there is exposed the basal member of the Cobleskill, 38 inches thick. This layer is hard and compact and except where weathered, fossils can be obtained from it only with difficulty. This layer is followed by one 16 inches thick, locally known as the marble layer on account of the beautiful polish which it takes. The marble layer is followed by thin layers 1 to 3 inches thick, having a somewhat sandy texture and quite fossiliferous.

The faunas from the different layers vary somewhat. In the thin layers at the top Camarotoechia? lamellata is very abundant and an undetermined species of Beyrichia occurs in large numbers. Chaetetes sp. and Tentaculites sp. undet. are also found in the thin layers. From the basal layer a single specimen of Leptaena rhomboidalis has been obtained. This species was also found at Clarke's cave west of Schoharie. It is however very rare in the Cobleskill of Schoharie county.[2]

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[1] Prof. Prosser has most courteously revised all his sections for this work so as to embody the results of his latest studies.

[2] Hartnagel, C. A. N. Y. State Mus. Bul. 69. 1903. p. 1120-21.

The following section will show the relation of the Cobleskill to the overlying rock as it is exposed in the nearly vertical wall of the Brown quarry.

Section of Brown quarry modified from Hartnagel's section

	Feet	Inches
Rondout		
e 7 Thin bedded, light colored waterlime	..	10
e 6 Blue lime mudrock with corals in fragment	2	1
e 5 Blue limestone with corals (like e 6)	2	1
e 4 Fine, somewhat argillaceous lime sandrock weathering earthy, with Favosites and Stromatopora, and with Camarotoechia? lamellata and other fossils	1	2
e 3 Clayey weathered layer with Favosites	..	4
e 2 Argillaceous lime mudrock with Favosites and Camarotoechia? lamellata	1	10
e 1 Shaly and clayey layers	..	10
Cobleskill		
d 3 Thin limestone layer somewhat arenaceous in texture	..	10
d 2 Limestone (marble layer)	1	4
d 1 Highly crystalline crinoidal lime sandrock with conglomeratic character, due to fragments of Favosites and Stromatopora. No complete heads were observed	3	2
Total Cobleskill	5	4
Brayman shales (c) exposed on roadside	1	

2 Section in Vroman's quarry

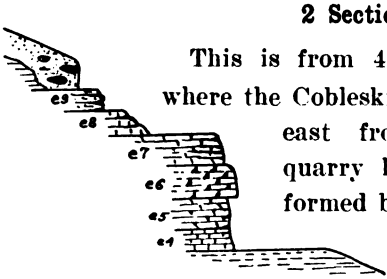


Fig. 190 Section of Vroman's quarry

This is from 400–500 feet south of the point where the Cobleskill crops out on the road leading east from Schoharie postoffice. The quarry has been opened in the terrace formed by the Cobleskill and Lower Rondout beds and in the lower part of which the Brown quarry is situated. The beds exposed in this quarry belong to the Rondout series (e), beds e1, e2 and e3 being absent here, but exposed in the Brown quarry.

The section [fig. 190] is as follows:

	Feet	Inches
Till, with numerous boulders	2	
Rondout waterlime		
e 9 Weathered lime mudrock, somewhat arenaceous in texture	1	3
e 8 Weathered lime mudrock similar to the preceding. [This and the next lower bed below the soil become porous through weathering, changing to a soft, friable and rotten rock.]	1	6
e 7 Lime mudrock weathering brownish in thin layers separated by shaly streaks which are discontinuous, the whole varying in thickness from 16 to 20 inches	1	6
e 6 Dark lime mudrock containing many small fragments of Favosites and Stromatopora. Some of these are overturned and all are fragmentary, showing much wearing. Stromatopora is more abundant than Favosites. The fragments are equally common in the upper and the lower portion of the bed, and they are almost abundant enough to make the rock a lime conglomerate with the corals forming the pebbles held in a muddy paste	1	9
e 5 A bed of somewhat more arenaceous texture but a very pure limestone in composition. It contains large heads of Favosites and Stromatopora, but most of them appear to be fragmentary or overturned. Between this and the preceding higher bed are some shaly layers containing small but complete heads of Favosites helderbergiae precedens and Stromatopora. With them occur Camarotoechia? lamellata and Leperditia cf. jonesi. The thickness varies from 18 to 21 inches	1	8

		Feet	Inches
e 4	More or less arenaceous lime mudrock similar to bed 5. It is rubbly from the presence of coral fragments. It is thin bedded with the bedding planes well marked. Contains F. helderbergiae precedens, often overturned. To base of quarry.............	1	

From the lower three beds Hartnagel obtained the following Cobleskill fauna, which is thus seen to extend up into the Rondout.

1 Favosites helderbergiae precedens
2 Stromatopora cf. antiqua
3 Camarotoechia litchfieldensis
4 Orthothetes interstriatus
5 Camarotoechia? lamellata
6 Spirifer corallinensis
7 Whitfieldella nucleolata
8 Pterinea securiformis
9 Orthoceras
10 Beyrichia
11 Leperditia cf. jonesi

	Feet	Inches
Total exposure of Rondout.....................	8	8

Twenty feet higher in the field are quarried 2 feet and 6 inches of dark lime mudrock, the upper 6 inches of which contain Spirifer vanuxemi, Leperditia alta, etc. The rock has a ringing sound when struck with a hammer, and between the layers are found occasional shaly streaks. It belongs to the Manlius beds.

3 Section of lower part of East hill at Mix and O'Reilly's quarry

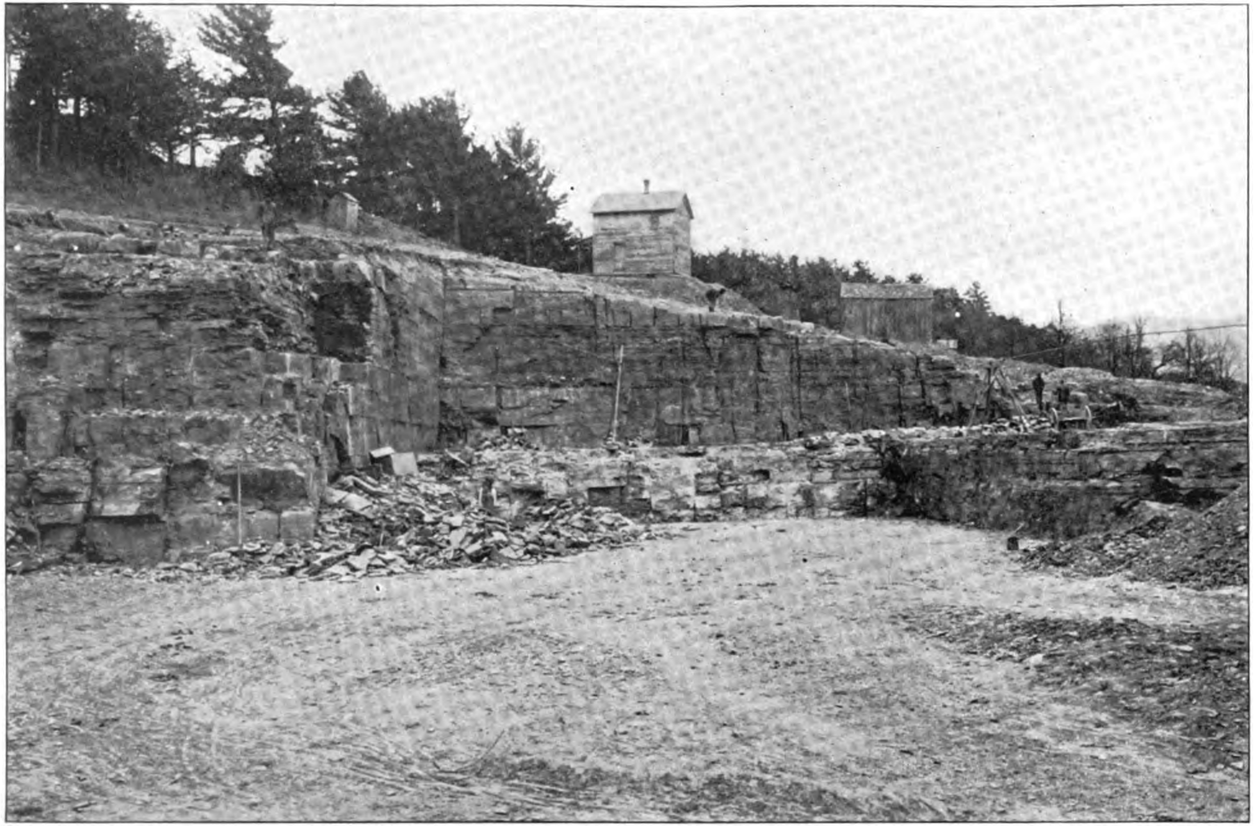
Plate 16

The section begins at the road above the quarry and continues downward to the lowest exposures near the stone crusher.

		Feet	Inches
Coeymans			
h 1	Coeymans limestone, about................	15	
Transition beds			
g 4-7	Covered	4–5	
g 3	Lime mudrock bed		6
g 2_2	Covered	3	

		Feet	Inches
g 2_1	Very fine lime sandrock, almost a mudrock, with Stropheodonta varistriata		6
g 1	Covered. Transition beds, about	3	
Manlius			
f 13	Manlius, about	5	
	Top of quarry		
f 12	Massive bed, like f 10, forming topmost layer of quarry	1	
f 11	Thin bedded dark fossiliferous lime mudrocks like f 9	4	
f 10	Massive finely stratified dark but rather argillaceous lime mudrocks with Spirifer vanuxemi	1	9
f 9	Thin bedded, irregular, finely arenaceous beds and some mudrocks full of the common fossils	3	6
f 8	Fine lime mudrocks similar to f 6 but in several thin and thick beds	3	4
f 7	Lime mudrocks, occasionally arenaceous in texture and in part shaly		3
f 6	Very fine grained, fossiliferous lime sandrocks, the upper portion nearly a solid mass of Tentaculites		9
f 5	Thin bedded, irregular lime mudrocks, with the usual fossils on weathered surfaces. Tentaculites gyracanthus is the most abundant but Leperditia alta and Spirifer vanuxemi also occur	1	3
f 4	Massive, like f 2 a single bed	2	6
f 3	Similar to f 2 but thin bedded and the beds varying in thickness	3	
f 2	Compact, massive, almost black lime mudrock, somewhat arenaceous conchoidal and fossiliferous	3	2

Plate 16



Mix & O'Reilly's quarry on East hill. Rondout at the base, Manlius in main cliff and Coeymans in lower cliff behind the trees on top

		Feet	Inches
f 1	Dark gray, irregularly bedded lime mudrocks		8
	Total Manlius	30	2
Rondout waterlimes			
e 15	Massive lime mudrocks with irregular but extremely fine bedding. These irregularities are like those found in the section of a mud bank. Sometimes portions are squeezed out into little humps, sometimes the laminae become irregular and curly or wrinkled. Small black subangular fragments of the underlying lime mudrocks are frequently common in the layers but they are so small that they are readily overlooked. In some cases these pebbles are most abundant in layers	1	6
e 14	Similar to (e12) in two layers	1	6
e 13	Massive lime mudrocks with fine banding on both fresh and weathered surface. Oscillation ripple marks are shown in the upper part of the section		9
e 12	Thin bedded, gray, fine layered lime mudrock becoming shaly when weathered		9
e 11	Dark, nearly black lime mudrock, rather massive bedded, in several tiers with splintery or conchoidal fracture, thin bedded on weathered surfaces but not shaly	3	
e 10	Lime mudrocks mostly covered and forming the floor of the quarry	5	
e 9 to e 1	Lime mudrocks, mostly covered [*see* section 2]	12	
	Total Rondout (e)	24	6

		Feet	Inches
Cobleskill			
d 1 to d 3	Cobleskill limestone in several beds, not well exposed	6	
Brayman			
c	Brayman shales, the higher beds exposed on the roadway leading up to the quarry, the lower in contact with the basal sandstones shown below the crusher—on railroad track. Thickness as measured by Hartnagel	27	
Binnewater			
b	Basal sandstones, a quartz sandstone of yellowish and reddish color, consists generally of almost pure quartz grains though some beds are slightly argillaceous. Lower beds thin, the upper thick bedded but saccharoidal and containing much pyrite like the overlying shales. Thickness estimated	20	
	Stratigraphic unconformity.		
Lorraine			
a	Lorraine sandstones (?) dark grayish or purplish silicious sandrock resembling the normal Hudson river sandrock of the Helderberg region, and resting on shales which have the appearance of the normal Hudson river shales in other parts of the Helderbergs. These beds are very unlike the more friable looking sandstones which underlie the Brayman shales conformably. This and the resemblance to the Hudson river beds are the only evidence so far obtained that the lowest beds of this section are Hudson river. They may however be-		

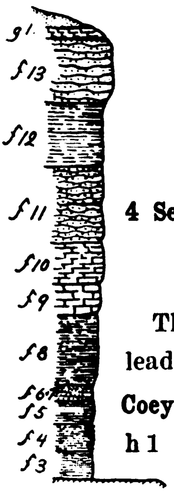


Fig. 191 Section of city quarry

long to the basal sandstone in which case the great stratic unconformity between the higher Champlainic and late Siluric beds is probably below the level of the Schoharie valley at this point.

4 Section of city quarry behind the Lutheran cemetery, Schoharie

Fig. 191 and pl. 17

This section extends to the top of the cliff at the stairway leading to the park behind the cemetery.

	Feet	Inches
Coeymans		
h 1 Typical Coeymans, coarse lime sandrocks with typical fossils, forming ledge in the woods above the cemetery. At the base the cliff is weathered back in a rock shelter, and it is here, in the lowest layers that *Melocrinus pachydactylus* was found.		
Thickness approximately.................	15	
Transition beds		
g 4-7 Covered slope with exception of small outcrops of fine lime sandrocks with *Stropheodonta varistriata*..	5	
g 3 Very fine lime sandrock almost lime mudrocks with *Stropheodonta varistriata*..........................	1	
g 2 Covered slope	5	
g 1 Irregularly bedded lime sandrocks and lime mudrocks forming upper portion of quarry wall	1	
Total transition	12	
Manlius		
f 13 Irregular beds passing into those above and forming cliff with it..................	4	

	Feet	Inches
f 12 Compact even lime mudrocks in two tiers with fine uniform banding.............	4	
f 11 Irregularly bedded mostly thin lime sandrocks, and lime mudrocks with Spirifer vanuxemi, in two tiers........	4	6
f 10 Dark lime mudrocks, fossiliferous and somewhat arenaceous in texture, with Spirifer vanuxemi. It forms a single massive bed and where weathered shows fine bedding lines	2	3
f 9 Massive lime mudrocks with layers of lime sandrocks made of shell fragments and whole shells, showing the irregular structure given in the annexed diagram [fig. 192] in the lower parts	2	5

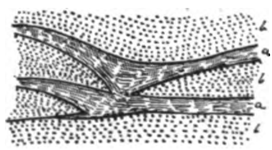
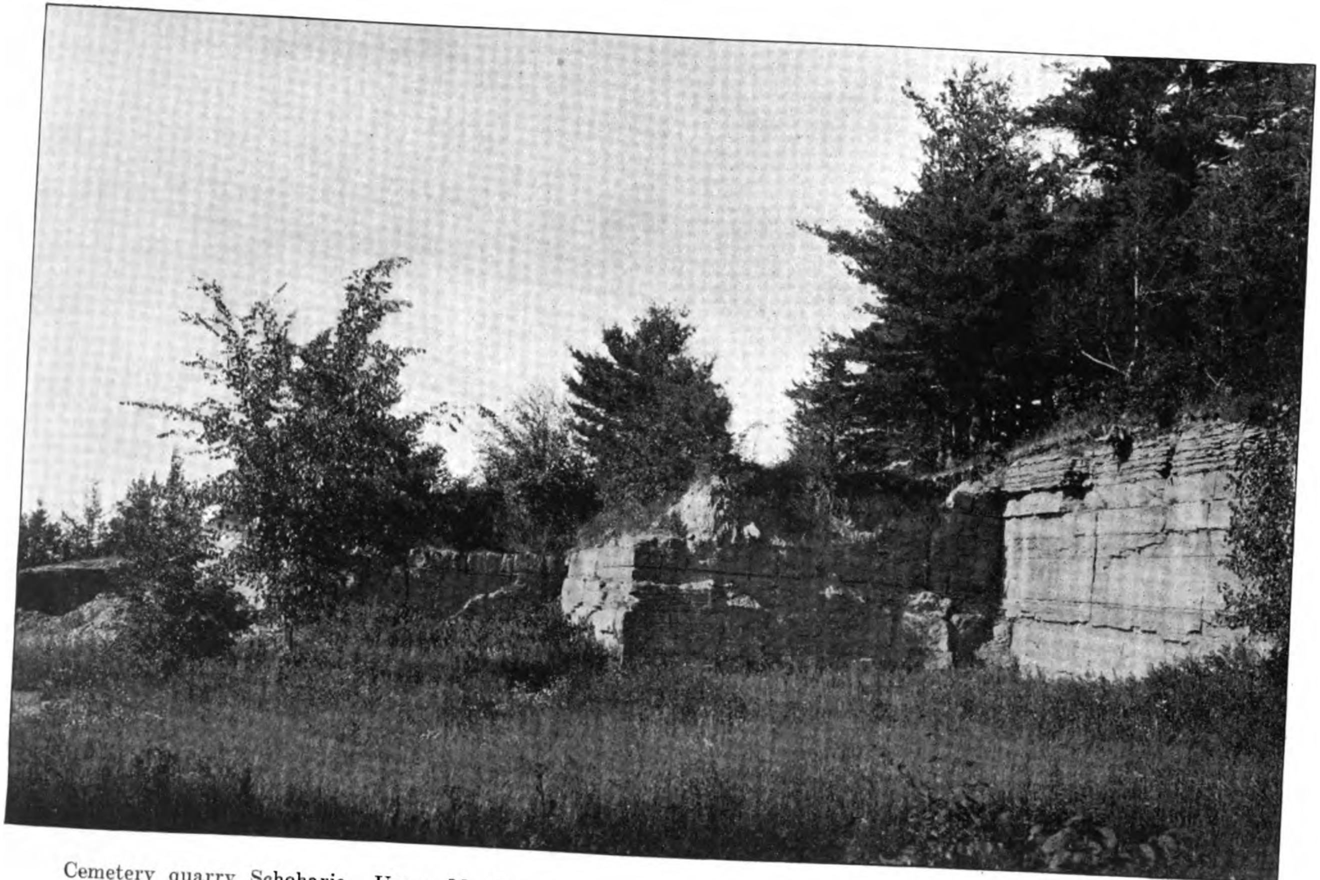


Fig. 192 Irregularity of stratification in Manlius. *a*, lime mudrock; *b*, lime sandrock

f 8 Thin bedded lime mudrocks and lime sandrocks much like f 5. On weathered surfaces Tentaculites is very abundant. In the upper part the beds become somewhat thicker and some are sandrocks made of shell fragments. Most of the beds are fossiliferous and unlike the usual type found in the Manlius farther east. Some of these beds show irregularity of bedding on the weathered surfaces. Extremely fine cross bedding is seen, and some of the layers swell out and then thin again as seen in fine sandstones generally. Some

Plate 17



Cemetery quarry Schoharie. Upper Manlius in main face of quarry; transition beds below the t

Feet Inches

of the beds thin out altogether, and at other times there is a rhythmic swelling and thinning, suggestive of oscillation ripples. A careful examination of the weathered edges of these strata will give one a good impression of the clastic character of these deposits. The wave action is almost as marked in these beds as in

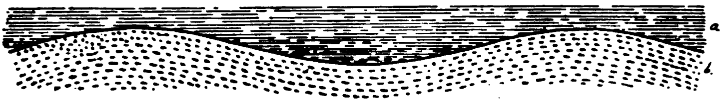


Fig. 193 Ripple structure in Manlius. *a*, lime mudrock; *b*, lime sandrock

any modern deposit of fine sand exposed in road cuttings.[1] The bedding of the fine lime mudrocks is such as to fill in by horizontal layers the depression in the lime sandrocks as shown in the annexed diagram [fig. 193]. Layers of lime mudrocks are eroded to form ripples as shown in figure 194.

Thickness of f 8 4

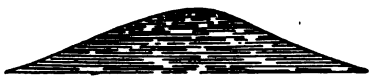


Fig. 194 Ripple structure in Manlius lime mudrock

f 6 & f 7 Lime sandrock, in places almost made up of Tentaculites; S p i r i f e r v a n u x e m i, with rounded and not very strong ribs occurs, approaching in character S. e r i e n s i s 11

[1] Some walls of the quarry, however, do not show this feature because they are coated with a layer of calcite, formed there while the wall bounded a joint fissure, by lime brought in in solution.

	Feet	Inches
f 5 Thin bedded lime mudrocks weathering gray and averaging an inch or less in thickness. Tentaculites gyracanthus is abundant on the surfaces of the thin layers, when weathered, and this is one of the best places for collecting this fossil. With it occur Spirifer vanuxemi and Monotrypella arbusculus	1	3
f 4 Lime mudrock somewhat arenaceous in texture with Leperditia alta and a few other fossils	2	
f 3 Dark lime mudrock, of sufficiently arenaceous texture to be rough on the weathered surfaces, and showing fine stratification on exposed edge, continuing below the floor of the quarry	1	6
Total Manlius exposed	26	10

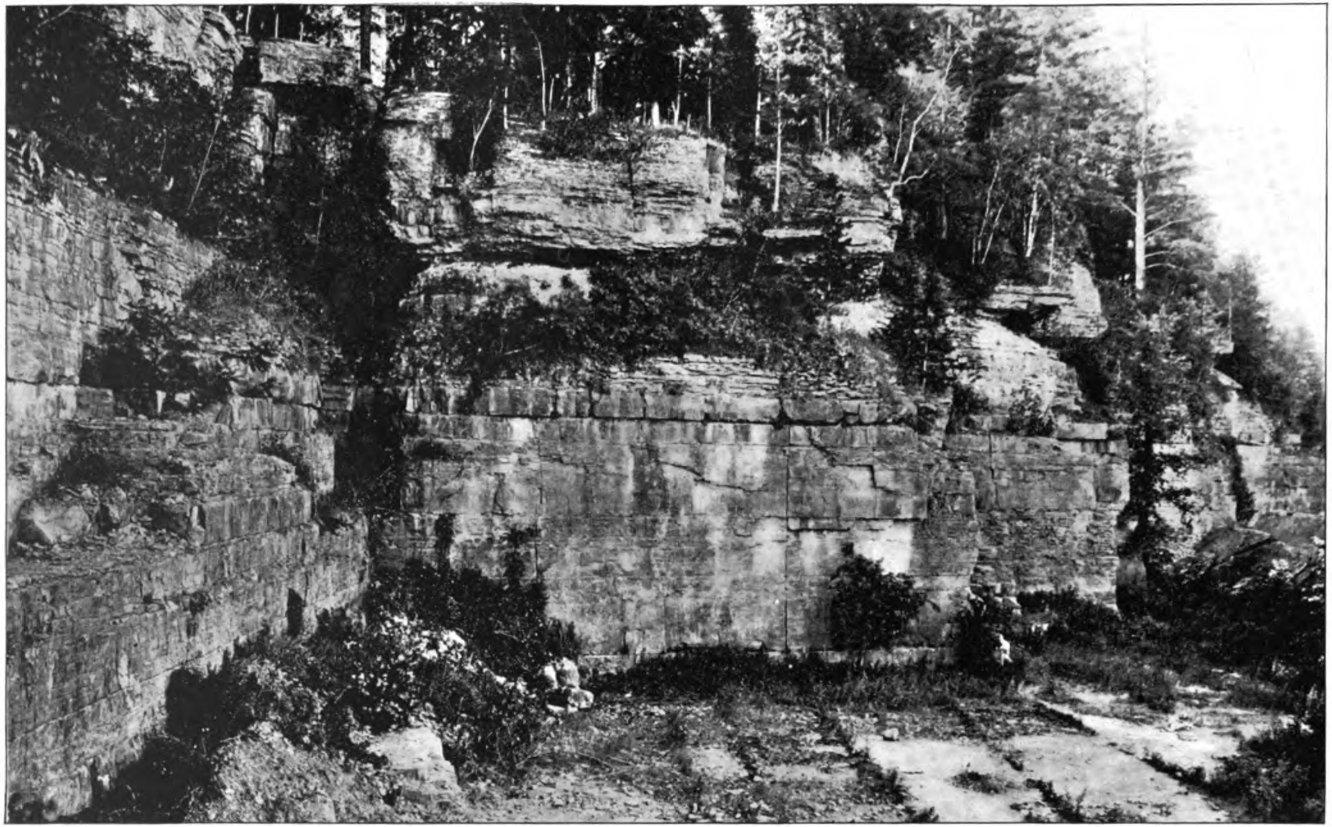
5 Section in Becker's quarry below Lasell park

Plate 18

This section begins at the highest outcrops of limestone in the bed of the small stream which traverses the park. The succession is as follows [fig. 195]:

Coeymans	Feet	Inches
h 2-hx Lime sandrocks with fossils, exposed at intervals in low ledges in the park, chiefly thin bedded and mostly covered	33	
h 1 Crystalline lime sandrock forming a cliff and containing Sieberella galeata, Orthothetes and other brachiopods, together with numerous crinoid joints	17	
Total Coeymans	50	

Plate 18



Becker's quarry looking south. Manlius in floor and lower face of quarry. Transition in retreating, brush covered portion, Coeymans in upper cliff. Lasell park on top

	Feet	Inches
Transition		
g 2-g 7 Thin bedded lime sandrocks and lime mudrocks, with shaly argillaceous beds, the whole weathering back in a slope, with the Coeymans overhanging	5	

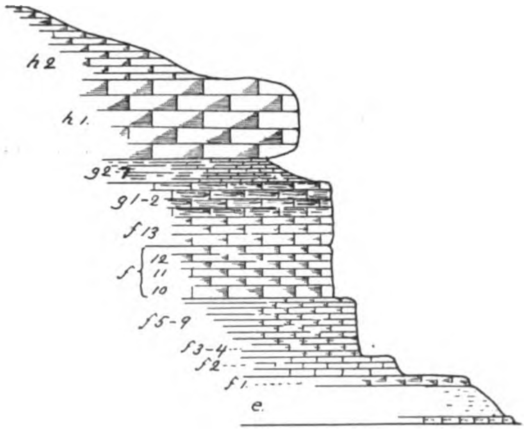


Fig. 195 Section in Becker's quarry

	Feet	Inches
g 1-g 2 Thin bedded limestones mostly weathering into a sloping bank and merging into the beds below and above. Approximately............	7	
Total transition	12	
Manlius		
f 13 Beds similar to g 1 and not readily separable from them	6	

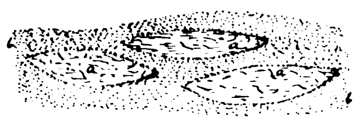


Fig. 196 Lenses of lime mudrock (a) n lime sandrock (b). Manlius

	Feet	Inches
f 12 Lime sandrocks like f 10 in two beds, 2 feet each, with a thin shaly parting............	4	
f 11 Irregularly bedded thin layered lime sandrock with lenses of lime mudrock [fig. 196]. The main mass of lime sandrock composed of shells and shell fragments................	5	

		Feet	Inches
f 10	Compact, irregularly bedded lime sandrock forming a single bed and very fossiliferous. Spirifer vanuxemi predominates. With f 11 and f 12 this forms a solid cliff...	2	
f 9-f 8	Lime sandrock showing composition of shell fragments on the weathered edge and rather thin bedded in appearance when weathered.	6	3
f 7-f 6	Heavy bedded lime sandrock, fossiliferous and chiefly made up of shell fragments........	1	3
f 5	Shaly lime mudrock with thin beds of Tentaculite limestone at the middle. Also contains Leperditia	1	3
f 4-f 3	Dark heavy bedded lime mudrock. The smooth weathered cross-section of the rock has a curious granular structure like grains of sand, which weather slightly in relief. They give the rock an oolitic appearance, which however is less apparent on fresh fracture. This feature, though shown in f 1 and 2, is eminently characteristic of this bed. In it also occur Leperditia alta and Spirifer vanuxemi though less commonly. Tentaculites gyracanthus also occurs............	4	6
f 2-f 1	Dark heavy bedded lime mudrocks with some of the layers banded. Contains Leperditia alta and Spirifer vanuxemi in abundance..................	3	
	Total Manlius exposed	33	3
Rondout			
e 12	Compact dark lime mudrock, exposed in the road, and apparently the bed forming the base of the quarry........................	1	
e 11-e 1	Concealed mostly	22	
Cobleskill			
d	Exposed in the road........................	1	

6 Section of syndicate quarry in the hillside behind Vroman's quarry

Figure 197 and plate 20

	Feet	Inches
Soil		
Coeymans		
h 1 B Dark tough lime sandrock showing where weathered innumerable Sieberella galeatus. These sometimes cover the weathered surfaces or edges, but are difficult to separate. Large fragmentary masses of Favosites helderbergiae are common and not infrequently lie overturned..................	15	

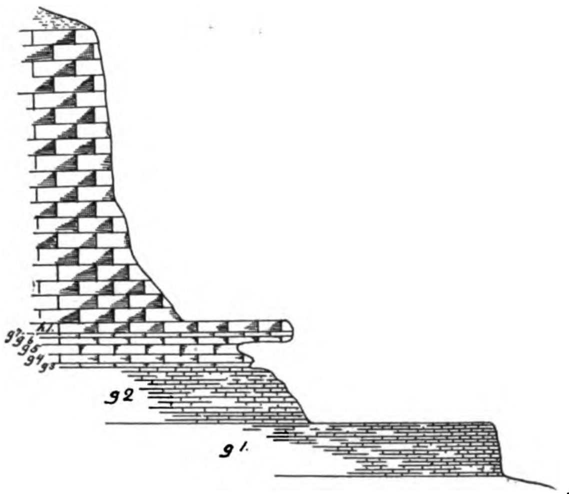


Fig. 197 Section of Syndicate quarry

	Feet	Inches
h 1 A Lime sandrock with large heads of Favosites helderbergiae and Stromatopora apparently in place	1	
Transition beds		
g 7 Limestone bed largely made up of Stropheodonta varistriata		4
g 6 Crinoidal lime sandrock		6
g 5 Dark gray lime mudrocks in lenslike masses embedded in shale and separated by shaly layer from g 6. The shales contain an abundance of		

	Feet	Inches
Stropheodonta varistriata, also Strophonella punctulifera, Pterinea textilis and occasionally Uncinulus mutabilis and Tentaculites. The limestone lenses contain Camarotoechia semiplicata var................		10
g 4 Fine lime sandrock with numerous crinoid joints which weather in relief....................		10
g 3 Shale with mud lenses, the latter with Camarotoechia semiplicata var.........		6
g 2 Lime sandrocks and lime mudrocks, alternating, thin bedded, mostly dark gray in color. Fossils most common are Camarotoechia semiplicata var., in the mudrocks and crinoid joints in the sandrocks. Other species are Stropheodonta varistriata, Spirifer vanuxemi and var. Camarotoechia ventricosa, Fenestella sp., Dalmanites sp. To base of quarry	5	6
g 1 Thin bedded gray lime mudrocks, somewhat arenaceous in the upper part, with occasional crinoid joints and with Stropheodonta varistriata and occasional Spirifer vanuxemi	4	8
Total transition beds	13	·2
Manlius		
f 13 Lime mudrock with Spirifer vanuxemi in abundance (upper part of bed).........		8
f 13 Lower part, to f 5. Mostly covered, exposures are found at intervals.....................	20	
f 4 (approximately). Ledges of a dark lime mudrock are quarried in the field half way between Vroman's and the Syndicate quarries. The rock has a ringing sound when struck with a		

Plate 19

Syndicate quarry, Schoharie. Upper Manlius in lower slope, transition beds in middle portion, Coeymans in upper part. The figure stands on basal Coeymans bed

		Feet	Inches
	hammer, occasional shaly streaks occur between the layers. The upper 6 inches contain abundant Spirifer vanuxemi and Leperditia alta	2	6
f 3 to f 1	Covered about	7	
	Total Manlius	30	2
Rondout			
e 15–e 10	Covered	14	8
e 9–e 1	Beds of Vroman's quarry [section 2] and Brown's quarry [section 1] total	14	6
	Total Rondout about	29	2

The total thickness of the Rondout and Manlius of this section was found by careful leveling with due correction for the dip to be 59 feet and 4 inches. In the Mix and O'Reilly section the Manlius was 30 feet and 2 inches, which, if no change has occurred in that formation, makes the Rondout here 29 feet and 2 inches. The Manlius may be thicker here in which case the Rondout is thinner. That the Manlius is not thinner is shown by the exposure of nearly 27 feet in the city quarry [section 4].

7 General section of East hill

		Feet	Inches
q	Hamilton fine grained sandstones and sandy shales with Stropheodonta, Spirifer and pelecypods to top of East hill (A. T. 1940 ft) forming a steep slope mostly wooded. Approximately	750	
p	Marcellus shale showing on Stony brook:		
p 5	Black fissile shales with the usual fossils, including Styliolina fissurella, dark blue gray or blackish in the upper part with Spirifer and Chonetes. About	140	
p 4	Limestone layers composed of Liorhynchus mysia and Strophalosia truncata occur here	1	
p 3	Covered	15	

		Feet	Inches
p 2	Agoniatite (Goniatite) limestone, a dark gray, impure limestone with *Orthoceras marcellense* and other fossils	2	
p 1	Mostly covered. Approximately	22	
	Total Marcellus	180	
	Forming a gentle cultivated slope, the contact with the overlying Hamilton forming a pronounced change of angle.		
o	Onondaga limestone forming a succession of rather steep slopes with frequent outcrops. The upper beds are cherty	105	
n	Schoharie grit, mostly covered, but weathered fragments are found on the slope of Esopus below [estimated]	6	?
m	Esopus shales. Chocolate-colored gritty shales much checked by weathering and mostly covered. *Spirophyton cauda-galli* in some of the higher beds	85	
l	Oriskany sandstone. Silicious limestone weathering to a brown porous sandrock in which the numerous fossils are preserved as molds. It forms broad terraces and fields along the hill. Approximately	2	4
k	Port Ewen limestones. (?)Gray crystalline limestones, not well exposed, grade downward into the Becraft. Estimated thickness about	6	
j	Becraft limestone. Best exposed in the upper Mix and O'Reilly quarry and in the cliffs below the highway to the north of this. Highly crystalline calcarenyte and often a shell rock or coquina. On the weathered surfaces the fossils stand out in relief. *Spirifer concinnus*, *Sieberella pseudogaleata*, *Aspidocrinus scutelliformis*, etc.	15	

		Feet	Inches
i	New Scotland beds, mostly covered but occasionally cropping out. Form sloping bank. Approximately	115	
h	Coeymans, forming a slope above and a cliff part of which has been quarried in the middle Mix and O'Reilly quarry and about 15 feet of which is exposed in the cliff above the lower quarry. Total	50	
g	Transition beds. Mostly covered. About	12	
f	Manlius as exposed in lower quarry [section 3]. Approximately	30	
e	Rondout, only the upper half of which is exposed in the quarry	24	6
d	Cobleskill, shown along the road opposite the stone crusher	6	
c	Brayman shales, exposed along the road and on the track below the crusher	27	
b	Basal sandstones (Binnewater) exposure estimated, since the contact with the Lorraine beds is not exposed	20	
a	Lorraine sandstones and shales, lowest exposure on the hill	? 5–10	
	Total rock section in East hill	1444	

8 General section of West hill

Fig. 198

The section of West hill is the most complete and most satisfactory. Some of the beds can best be studied along the road leading up to West hill along Dann's hill. The road begins at the point where the East Cobleskill road branches off, and climbs to the Coeymans terrace on Dann's hill by a cut in the upper Manlius and lower Coeymans. It continues on this terrace to a short distance beyond the stream which divides Dann's hill from West hill, and then turns sharply to the left, climbing the

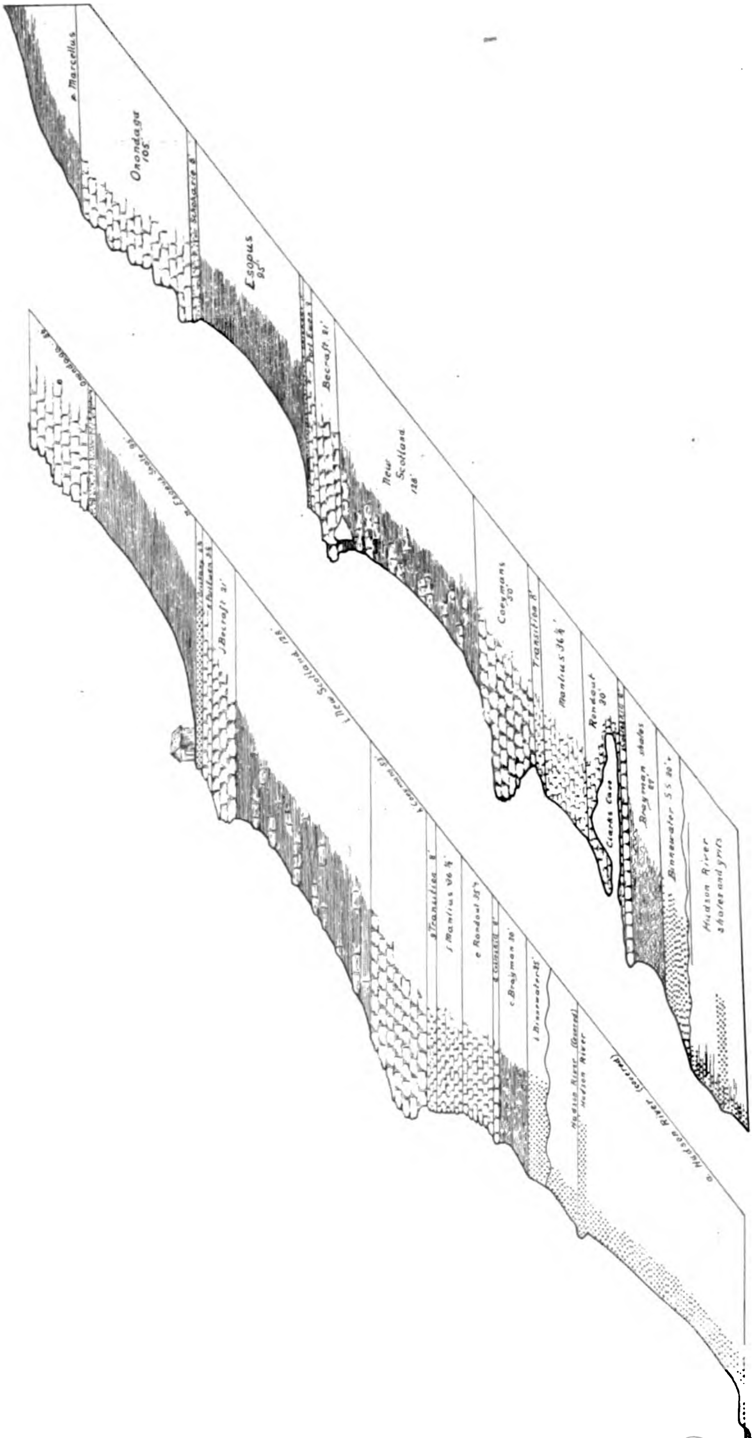


Fig. 199 Section of Dann's hill, Schoharie

Fig. 198 Section of West hill, Schoharie

New Scotland slope to the Becraft Oriskany terrace, which is reached by a final ascent over Becraft ledges. On this terrace it continues to the home of Mr George Acker, near which the following section is made. A section of this hill was published by Prosser.[1] The present section is largely based on that but some corrections of measurement are made.

	Feet	Inches
o Onondaga limestone, forming the upper limestone cliffs and the top of the hill which is wooded. From 11 to 15 feet are shown in the cliffs. The total thickness present is, according to Prosser	56	
n Schoharie grit, not exposed on this side of the hill, estimated	6–8	
m Esopus shale, not exposed, except at the top where large slabs with Spirophyton caudagalli occur but forming with the Schoharie a continuous steep slope from the Oriskany terrace to the cliff of Onondaga[2]...	95	
l Oriskany sandstones, well exposed in the yard of George Acker. The red barn visible from Schoharie stands on the top of this bed, where the upper hard surface, marked by Spirophytonlike tracings, have been laid bare by erosion of the Esopus. Fossils numerous and easily obtained from the loose blocks lying everywhere	6	3
k Port Ewen limestones, a dark rather fine crinoidal lime sandrock resembling the Coeymans. Approximately	9	3
j Becraft limestone, forming a cliff below the road in front of Mr Acker's house, 15½ feet		

[1] N. Y. State Geol. 18th An. Rep't. 1899.

[2] Prosser writes me that his section included the 6 feet of Schoharie grit. For that interval the barometer gave 108 feet; but it was leveled with a hand level by an engineering student who reported 121 feet and that thickness was used in his section.

	Feet	Inches
high. Above this is a slope comprising 5 feet of the uppermost Becraft	21	
i New Scotland beds. Shaly limestones forming the middle covered slope of the hill. On the surface are numerous fragments of weathered rock on which the fossils stand out in relief. This is as good a collecting ground of this formation as any in the Schoharie region. The upper beds, consisting of a series of argillaceous mudrocks with alternating layers of concretionary limestone, are shown better along the rock shelters and at the arch above Sam Clark's house on Dann's hill [fig. 199]. Along the contact line with the Becraft here as well as at Acker's characteristic fossils are found. The upper layers are very calcareous and contain Aspidocrinus scutelliformis [pl. 12]	128	
h Coeymans limestone, massive, dark gray limestone, chiefly a lime sandrock. The lower $27\frac{1}{2}$ feet form an overhanging cliff, from which a fine view of the valley below may be obtained. The remainder forms a slope, rising about 25 feet in 125 horizontal distance. The upper beds are full of fossils which may be obtained from the outcropping ledges. Thickness of Coeymans	53	
g Transition beds. Weathering back and causing the Coeymans to overhang. Prosser finds 8 feet in this section. While the Manlius is correspondingly thicker, the two have a thickness of $44\frac{1}{2}$ feet as against 43 feet on East hill	8	
f Manlius limestone with Spirifer vanuxemi in the highest beds and shaly beds with Tentaculites and other fossils	36	6

		Feet	Inches
e	Rondout waterlime, thin bedded drab colored impure limestones, forming upper part of the waterlime	10	
	At the old strontium mine, $\frac{1}{2}$ mile farther north, the following succession occurs [pl. 24]:		
eh	Massive beds		
eg	Shaly gray beds with much clay and much decomposed. Split up thin. About........	8	
ef	Gray thin bedded lime mudrocks........		8
ee	Dark massive lime mudrocks forming a single bed	2	2
ed	Thin bedded impure lime mudrocks weathering into a yellowish argillaceous chalky rock. Leperditia cf. jonesi was found here.	3	
ec	Dark lime mudrocks in heavy beds and without the thin bedding of the lower beds. Numerous large geodes filled with calcite in crystals or massive, and strontianite in the white massive form, occur. Some of the geodes appear to have replaced heads of Stromatopora.....	5	
eb	Gray thin bedded waterlimes often quite argillaceous and showing fine stratification. Typical waterlime........	4	
ea	Dark gray massive lime mudrocks with conchoidal fracture. Lowest beds exposed......	2	
	e, eg and eh probably are the same as the 10 foot bed exposed in the section below Acker's.		
e to a	Mostly covered slope from the creek level to the base of the prominent cliff. The Cobleskill limestone (d) is exposed at several places on the lower slope, but the other beds are covered by talus. About 100 feet below the base of the cliff occur ledges of sandstone, probably in the Lorraine	260	
	Total of section approximately.........	706	

9 Section of north slope of Sunset hill

Prosser

To the south of Howe's cave and Cobleskill creek is a steep hill, rising about 1000 feet above the level of the creek. This is the northern slope of Sunset hill, and it affords a fair section of the formations in this region. The following gives their approximate thickness.

		Feet	Total
p–q	*Marcellus and Hamilton* formations from the highway to the top of the hill; but the slope is mostly covered. Fine pieces of Marcellus shale occur on the lower part of this slope, and thin Hamilton sandstones were seen toward the top of the hill	528	965
o	*Onondaga limestone;* massive, light gray limestone forming low ledges to the level of the highway	95	437
n	*Schoharie.* Covered, included in preceding		
m	*Esopus black shales,* which weather to a grayish color; mostly covered, but 8 feet showing in an excavation south of the old house and about 35 feet above their base	100	342
l	*Oriskany sandstone,* very fossiliferous; upper part a very dark gray to blackish quartzose sandstone; lower part lighter gray. Well exposed, in contact with the subjacent shaly limestone, just west of an old house, where it is from 1½ to 2 feet thick	2	242
k	*Port Ewen shaly limestone;* rather thin bedded, light gray limestone in which there are fossils.	11	240
j	*Becraft;* massive, light gray limestone, forming a steep ledge from 15 to possibly 18 feet in thickness	15	229
i	*New Scotland shaly limestone;* mostly a covered slope with only a little of the limestone shown at the top of the formation	95	214

	Feet
h *Massive Coeymans limestone,* the lower ledge 22¾ feet thick; then a covered slope with a shattered ledge at the top..................	53–119
d to g *Covered* from the level of the Cobleskill to the base of the lowest massive limestone, which is apparently about at the junction of the Manlius and Coeymans.......................	66–66

10 Section of strata at the quarries of the Helderberg Cement Co. near Howes Cave

Plates 4, 7, 8 and 20

	Feet	Inches
15 Coeymans		
Manlius		
14 Thin bedded lime mudrocks	12	
13 Massive dark gray lime mudrock " upper curly bed "	3	8
12 Thin and irregularly bedded lime mudrocks like bed 8..	5	10
11 Massive dark gray lime mudrocks in a single bed. This is known as the lower curly. It does not split on the bedding plane but has a conchoidal fracture. It varies in thickness from 3½ feet in one part of the quarry to nearly 5 feet in another. In some portions it is arenaceous in texture. Average	4	
10 Dark lime mudrocks in beds from 1 inch to a foot, irregularly bedded, sometimes rather shaly, to quarry floor..................................	10	
9 Thin bedded ribbon lime mudrocks...............	7	3
Total Manlius............................	42	9
Rondout		
8 Shaly, highly argillaceous lime mudrocks.........	10	
7 Massive bluish lime mudrocks.....................	4	
6 Shaly argillaceous lime mudrocks to railroad track (main line)................................	6	
5 Concealed, about	12	

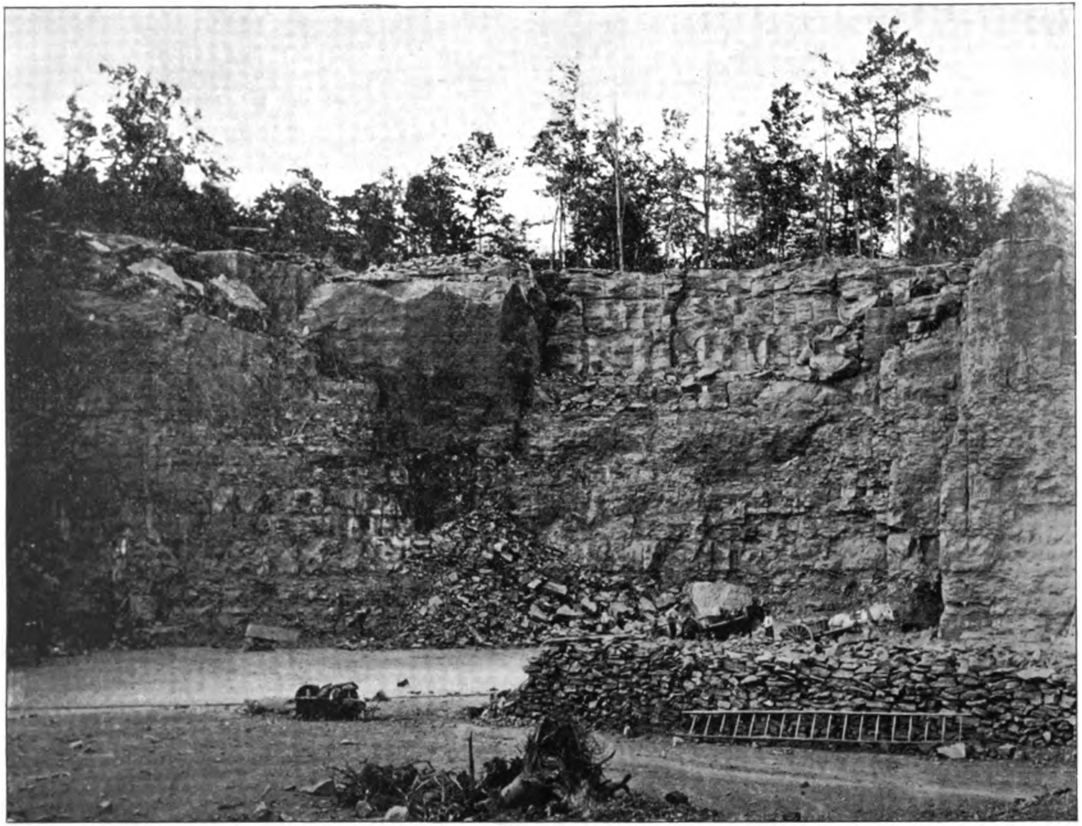
	Feet	Inches
4 Very thin bedded lime mudrocks, in layers often a quarter of an inch or less in thickness. They are finely stratified and contain much clay, and occasionally lenslike masses, a few inches thick, of lime sandrock. Weathers gray and brown. No fossils. About	10	
3 Cement bed. Lime mudrocks with fragments of Favosites, also small heads in the lower portion. The rock has a conchoidal fracture, is bluish gray when fresh but weathers brownish	6	
Total Rondout	48	
2 Cobleskill	6	
1 Brayman shales exposed	30	
Total	126	9

11 Section of north end of Moheganter hill

Prosser

On the eastern side of the river one mile south of Middleburg and about east of the prominent hill on the western side of the river known as Vroman's Nose, are ledges of sandstone and shales along the lower slope of the northern part of the Moheganter hill. The base of these rocks is approximately 160 feet above the Schoharie river at Middleburg and 200 feet of the section was studied, the upper ledge being a heavy sandstone stratum. The dip is heavy, being 2½° s. 85° w. in one place that was measured and on another ledge 2½° s. 50° w. The lowest rocks are not very coarse but rather argillaceous shales in which fossils are rare. Then the shales change to a coarse texture, are more arenaceous, Spirifer granulosus (Con.) Hall is common and a few other species occur. Above is a bluish, blocky sandstone succeeded by arenaceous shales in which Chonetes coronatus (Con.) Hall is common. And so the slope of the hill is terraced by ledges of sandstone and coarse shales which dip quite rapidly to the south. In the lower arenaceous shales and blocky sandstones fine specimens of Spirophyton velum (Van.) Hall are common. These rocks are all in the Hamilton formation and probably in its lower half. The fossils are:

Plate 20



Helderberg Cement Co.'s quarry, Howes Cave. Manlius in floor and lower two thirds of quarry face; Coeymans in upper third

1 Spirifer acuminatus (*Con.*) *Hall* rr
2 S. granulosus (*Con.*) *H. & C.* a
3 S. mucronatus (*Con.*) *Bill.* c
4 S. audaculus (*Con.*) *H. & C.* rr
5 S. tullius *Hall* rr
6 Chonetes coronatus (*Con.*) *Hall* c
7 C. deflectus *Hall* rr
8 C. mucronatus *Hall* rr
9 Orthothetes chemungensis (*Con.*) *H. & C.* var. arctostriatus *Hall* rr
10 Athyris spiriferoides (*Eaton*) *Hall* r
11 Stropheodonta perplana (*Con.*) *Hall* rr
12 Camarotoechia congregata (*Con.*) *H. & C.* rr
13 Liorhynchus multicostum *Hall* rr
14 Paracyclas lirata (*Con.*) *Hall* r
15 Goniophora rugosa (*Con.*) *Miller* rr
16 Modiomorpha concentrica (*Con.*) *Hall* rr
17 Glyptodesma erectum (*Con.*) *Hall* rr
18 Spirophyton velum (*Van.*) *Hall* r

12 Section along the Little Schoharie creek, in the southern part of Middleburg and the northwestern part of Broome township, from 2½ to 3 miles south of the village of Middleburg and on the eastern side of Moheganter hill

Prosser, section D

The first rocks studied are those of a small stone quarry [D^2] in the southern part of the township about 2½ miles south of the village. According to the barometer the quarry is some 830 feet higher than the Schoharie river at Middleburg. At the base of it are 6 feet of blue sandstone covered by 15 feet of shales with some thin layers of sandstone. In the shales are plenty of Hamilton fossils; specially in the thin layers and in some that have a rather concretionary structure. The rocks of this quarry are in the Hamilton formation and the following fossils were collected:

1 Spirifer granulosus (*Con.*) *H. & C.* (?) c
The specimens are poorly preserved. Some show impressions of the pustules and one shows fine striæ; but in form and general appearance they are like the above species.
2 Camarotoechia congregata (*Con. H. & C.*) r
3 Spirifer mucronatus (*Con.*) *Bill.* c
4 Chonetes coronatus (*Con.*) *Hall* r
5 Athyris spiriferoides (*Eaton*) *Hall* rr
6 Palaeoneilo maxima (*Con.*) *Hall* r
7 P. emarginata (*Con.*) *Hall* rr
8 P. tenuistriata *Hall* rr
9 Nuculites triqueter *Con.* r
10 Nucula bellistriata (*Con.*) *Hall* c
11 N. randalli *Hall* rr
12 Paracyclas lirata (*Con.*) *Hall* r
13 Modiomorpha subalata (*Con.*) *Hall* (?) rr
Small specimens.
14 M. mytiloides (*Con.*) *Hall* rr

15 Goniophora hamiltonensis (*Hall*) *Miller* rr
16 G. truncata *Hall* rr
17 Cimitaria elongata (*Con.*) *Hall* r
18 Tellinopsis subemarginata (*Con.*) *Hall* (?) rr
19 Sphenotus solenoides *Hall* (?) rr
There are no vascular lines on the posterior part of the shell.
20 Microdon (Cypricardella) tenuistriatus *Hall* c
21 Schizodus appressus (*Con.*) *Hall* r
22 Actinopteria boydi (*Con.*) *Hall* c
23 Pterinea flabellum (*Con.*) *Hall* rr
24 Limoptera macroptera (*Con.*) *Hall* rr
25 Pterinopecten undosus *Hall* (?) rr
26 Aviculopecten princeps (*Con.*) *Hall* (?) rr
27 Orthoceras crotalum *Hall* rr
28 Orbiculoidea (Lindstroemella) aspidium *H. & C.* rr

Approximately 340 feet above the stone quarry and south of the highway up the hill in northwestern Broome, just over the township line, is a small excavation showing blue sandstone (D^4) which splits into rather thin layers. No fossils were found in the bed rock; though there are plenty in loose pieces of stone on the surface which, however, probably came with the drift. On the highway just after it turns south in the northwestern corner of Broome and 145 feet above D^4 are green shales and thin sandstones (D^6) which are in the Sherburne formation. On the highway 30 feet higher near the turn to Franklinton are red and green mottled shales and sandstones (D^8). Another prominent terrace of grayish, slightly reddish and greenish shaly sandstone (D^{10}) appears 65 feet higher. Below this terrace along the highway are shales which are mainly red. At the top of the ridge is grayish and greenish gray, coarse grained, thin bedded sandstone (D^{12}). In the field plenty of loose red sandstone is found. The summit of the hill in the eastern part of Fulton township is only about 35 feet higher and this summit according to the barometric section is 1500 feet above the Schoharie river at Middleburg.

The rocks from D^8 to the top of Moheganter hill have in general the lithologic characters of the Oneonta formation to which they would ordinarily be referred. The reds and greenish gray rocks on this hill, however, appear stratigraphically much lower than the base of the Oneonta sandstone in the Susquehanna valley or even in the western part of Schoharie county, so that they have nearly, if not completely, replaced the rocks of the Ithaca formation. This fact will be shown still more clearly by the section of the western side of the Moheganter hill in the eastern part of Fulton township. This section southeast of Middleburg and up the eastern side of Moheganter hill is shown in the following diagram.

Summary of the section up the Little Schoharie creek

1500′		Top of Moheganter hill at corners	
	35′		
1465′		D^{12} Grayish and greenish sandstone	
	35′		
1430′		D^{10} Grayish and greenish sandstone	
	65′		Oneonta
1365′		D^{8} Red and green mottled sandstone and shale	
	30′		
1335′		D^{6} Green shales	
	145′		Sherburne
1190′		D^{4} Thin blue sandstone	
	340′	D^{3} Covered	
850′			
	20′	D^{2} Quarry of blue sandstone and shale	
830′			Hamilton
	515′	D^{1} Mainly covered	
315′		Bridge across creek 2½ miles s. e. of Middleburg	
	315′	D^{1} Covered	
0′		Schoharie river at Middleburg	

13 Section of western slope of Moheganter hill

Prosser, section C; fig. 200

Three miles southwest of Middleburg village, near the schoolhouse of district no. 11, the face of the hill is cut by a small brook and at this locality, a road leaves the river road and climbs to the top of the high hill. A section was measured from the level of the Schoharie river along the brook and highway to the top of the hill at this locality, which from a geological standpoint is a very interesting study. The section is near the Middleburg-Fulton township line being partly in each township, and its base is about opposite Watsonville on the western side of the river. The lower 200 feet are covered, largely by sand; but then a ledge of coarse, arenaceous shales and thin sandstones (C^2) is reached.

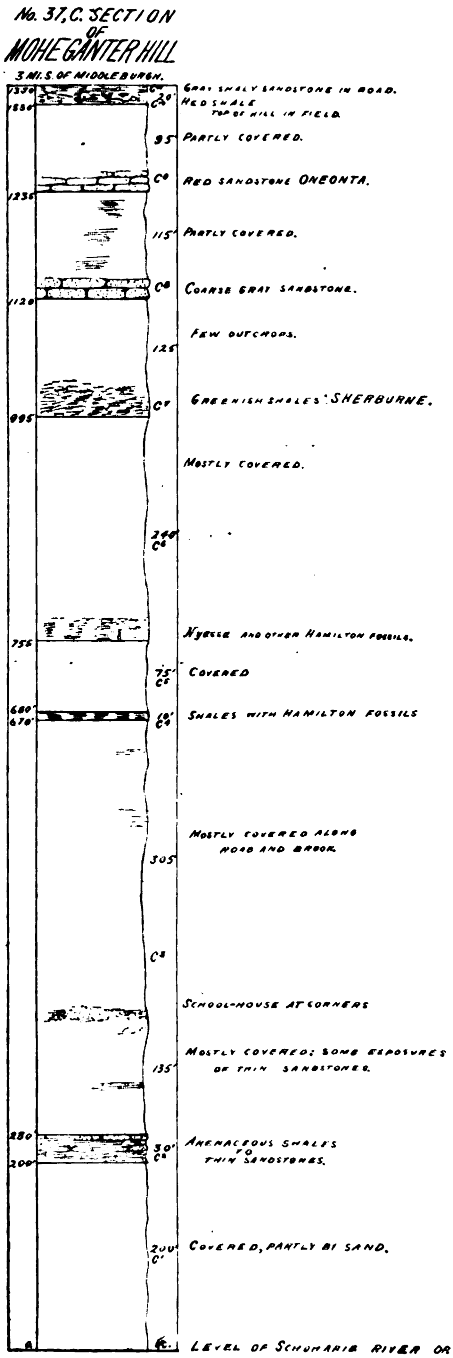


Fig. 200 Section of west slope of Moheganter hill. (After Prosser)

This ledge is in the woods where it forms a cliff 30 feet high. The dip is between 1½° and 2° s. 70° w. The rocks contain abundant Hamilton fossils and belong near the middle part of the formation. The following fauna was obtained:

1 Spirifer mucronatus (*Con.*) *Bill.* c
2 S. granulosus (*Con.*) *H. & C.* rr
3 Athyris spiriferoides (*Eaton*) *Hall* c
4 Camarotoechia congregata (*Con.*) *H. & C.* r
5 Microdon (Cypricardella) tenuistriatus *Hall* (?) rr
Imperfect and worn.
6 Chonetes mucronatus *Hall* c
Specimens larger than the figures of this species.
7 Chonetes deflectus *Hall* c
8 Palaeoneilo tenuistriata *Hall* rr
9 Macrodon hamiltoniae *Hall* rr
10 Grammysia bisulcata (*Con.*) *Hall* r
11 Tellinopsis subemarginata (*Con.*) *Hall* rr
12 Pterinea flabellum (*Con.*) *Hall* rr
13 Cyrtolites (Cyrtonella) pileolus *Hall* rr

From the top of this ledge for 135 feet to the schoolhouse at the road corners there are occasional outcrops of arenaceous shales, and then for 305 feet along the road and brook the rocks are mostly covered. By the side of the highway just above the house of Mr George P. Bouck and about one mile above the river road is an outcrop of from 8 to 10 feet of Hamilton shales (C^4). Those at the base are rather fine but the upper ones are coarser. The shales are mainly argillaceous and contain numerous Hamilton fossils. The list is:

1 Spirifer mucronatus (*Con.*) *Bill.* r
2 Cryptonella (Eunella) lincklaeni *Hall* c
3 Athyris spiriferoides (*Eaton*) *Hall* rr
4 Productella dumosa *Hall* (?) rr
5 Camarotoechia prolifica (*Hall*) *H. & C.* rr
6 Goniophora hamiltonensis (*Hall*) *Miller* rr
7 Nuculites oblongatus *Con.* rr
8 Palaeoneilo constricta (*Con.*) *Hall* rr
9 Cimitaria elongata (*Con.*) *Hall* (?) rr
Imperfect.
10 Actinopteria boydi (*Con.*) *Hall* c

75 feet higher and 755 feet above the Schoharie river are very thin, bluish, argillaceous shales (C^6). In a layer of somewhat coarser shales is an abundance of specimens of N y a s s a a r g u t a Hall; while a little higher are some thin layers of concretionary sandstone. These shales are referred to the Hamilton formation and the following fossils were collected.

1 Cryptonella (Eunella) lincklaeni *Hall* c
2 Athyris spiriferoides (*Eaton*) *Hall* a
Abundant in a layer of thin, shaly rock.
3 Camarotoechia prolifica (*Hall*) *H. & C.* a
Abundant in same layer as above.
4 Spirifer mucronatus (*Con.*) *Bill.* rr

5 Nyassa arguta *Hall* aa
6 Paracyclas lirata (*Con.*) *Hall* rr
7 Goniophora hamiltonensis (*Hall*) *Miller* rr
8 Pterinea flabellum (*Con.*) *Hall* rr
9 Liopteria bigsbyi *Hall* rr
10 Cyrtolites (Cyrtonella) mitella *Hall* rr

By the roadside 240 feet higher and 995 feet above the Schoharie river are thin, greenish, argillaceous shales and some that are arenaceous (C^7). These shales are referred to the Sherburne formation which they closely resemble in lithologic appearance. For the succeeding 125 feet the rocks are well covered though there is an occasional outcrop of the greenish shales; then a coarse grained, greenish gray sandstone (C^8) with cross-bedding is reached. Then the slope for 115 feet is partly covered with an occasional outcrop of the grayish to greenish sandstone. 55 feet above the lowest ledge of these sandstones are thinner gray sandstones, and in some rather shaly layers a few imperfectly preserved fossils were found—a remnant of the Ithaca fauna—which at that locality, by the changed conditions of deposition had narrowly escaped extermination. At 1235 feet above the river level is a thick, unusually hard ledge of reddish, indurated sandstone. Above, the slope though partly covered, shows frequent outcrops of red and greenish shales. 95 feet above the top of the reddish sandstone at the top of the brow of the hill are soft, argillaceous red shales. On the highway, about 20 feet higher are grayish, shaly sandstones (C^{11}) and 50 feet higher is another outcrop of coarse grained, greenish gray sandstone. The bedding is somewhat irregular but not thick and there is a layer of breccia. The only fossils found in place in these upper deposits were fragments of plant stems. By the side of the road, in loose pieces above the red shales, specimens of Tropidoleptus carinatus (Con.) Hall, Spirifer mucronatus (Con.) Bill. and Camarotoechia prolifica (Hall) H. & C. were found. It is not probable, however, that these fragments came from this part of the hill, but they were undoubtedly left by the ice sheet near the summit of Moheganter hill. On a stone wall in this vicinity large flat blocks of sandstone were seen which contained the following species, the first one occurring in large numbers:

1 Chonetes coronatus (*Con.*) *Hall* aa
2 Tropidoleptus carinatus (*Con.*) *Hall* a
3 Camarotoechia prolifica *Hall* c
4 Spirifer mucronatus (*Con.*) *Bill.* r
5 Athyris spiriferoides (*Eaton*) *Hall* r

From this last outcrop to the top of the hill at the corners, mentioned in section of eastern slope of this hill, is 40 feet, which

makes it 1440 feet above the level of the Schoharie river at its base. The barometric section from Middleburg village up the Little Schoharie and the eastern slope of the Moheganter hill to the road corners made it 1500 feet; so in the elevations there is probably not a very serious error in the case of either section. . . . . On account of the covered slope it is not possible to indicate closely the line of division between the Hamilton and Sherburne formations. There are at least 755 feet of rocks above the level of the Schoharie river belonging in the Hamilton, and probably part of the succeeding covered 240 feet belongs in the same formation. The 240 feet above the covered zone to the base of the heavy red sandstone is referred to the Sherburne and Ithaca formations, the thickness of which probably should be increased by a portion of the underlying zone. The rocks from the base of the red sandstone (C^9) to the summit of the hill are referred to the Oneonta formation. It is clearly recognized that to the west of the Schoharie river, rocks at this horizon are not red and are not called Oneonta but are referred to the Ithaca formation. A little farther east, however, along the Schoharie–Albany county line and to the eastward, the red rocks near this horizon and still lower have been mapped and correlated with the Oneonta formation. In that region it is impossible to follow any line of division between the Ithaca and Oneonta formations, for the Oneonta has replaced the Ithaca in the same manner as the Catskill replaces the Chemung in Delaware county, and the author [Professor Prosser] considers it advisable to follow the precedent of the state survey and so apply the term Oneonta formation to these rocks though it is quite true that they are synchronous with rocks which in the Susquehanna valley are referred to the Oneonta, Ithaca and upper Sherburne formations.

14 Section of Vroman's Nose

Prosser

To the southwest of Mill creek is Vroman's Nose which rises some 600 feet above the level of the Schoharie river. The lower part of the southern face has a steep slope largely covered by debris from the upper part of the hill, while the upper portion is a perpendicular cliff composed mainly of coarse arenaceous shales and sandstones. It is certainly a commanding hill when seen from its foot or at Middleburg, and when seen from the much higher hills to the southwest it looks like a hill blocking the Schoharie valley. A picture of this hill which, unfortunately, like photographs since taken does not give a very distinct impression appears in Emmons's *Agriculture of New York*. The hill was

studied in a rather hurried manner but, approximately, 250 feet above the river is the base of the rocks which continue for 370 feet to the top of the hill (A^4). The lower rocks are dark gray shales above which, toward the top of the hill, are rather blocky shales and thin sandstones. Hamilton fossils occur in the shales in moderate abundance while in some of the coarse, shaly sandstones there are numerous specimens of Spirophyton and Spirifer granulosus (Con.) H. & C. These rocks all belong in the lower part of the Hamilton formation and according to the Sherwood measured section there are 372 feet exposed in the hill, below which are about 200 feet covered.[1] On the bare sandstone ledge at the summit of the hill are conspicuous glacial striae, some of them quite deep, which run w. 10° s.

The following is an approximate section of Vroman's Nose.

Section of Vroman's Nose

610′		Top of hill
		Arenaceous shales and sandstones Hamilton A^4 Shales
250′		
	150′	A^3 Covered
90′		
	15′	A^2 Approximate position of the 15′ of Marcellus shale on Mill creek
75′		
	75′	A^1 Covered
0′		Schoharie river

15 Section along Panther creek from the Schoharie river to about two miles below West Fulton and then up the hill to the southwest of the creek

Prosser, section X, fig. 201

For about 90 feet along the lower part of Panther creek the rocks are mostly covered when the foot of the gorge at Bouck's falls is reached. This narrow glen is lined by cliffs of coarse shales and thin sandstones (X^1) which are apparently over 100 feet in height. Picture rock, on the southern bank a little below the falls is some 85 feet above the creek level below the falls; to

[1] Am. Phil. Soc. Proc. 17:348. [*See* section 18 beyond]

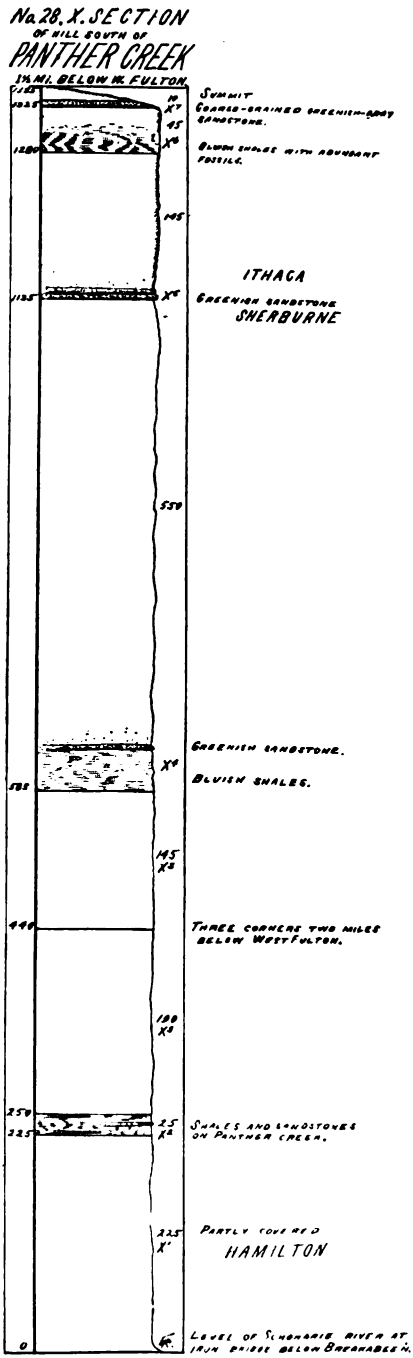


Fig. 201 Section on Panther creek

the top of the shales under the hotel is approximately 130 feet, or some 220 feet above the Schoharie river level. The gorge is narrow, indicating its recent formation and has been cut from rocks of Hamilton age. Some distance farther up the creek and perhaps not much higher than the top of the shales in the cliff at Bouck's falls is the upper end of the gorge. The rocks (X^2) consist of shales and sandstones, some of the latter being quite massive. On the northern side of the creek the exposure is some 25 to 30 feet in height and is labelled Blarney stone. The dip is apparently heavy, being about 4° s. 30° w. Some of the shales contain numerous specimens of Spirifer granulosus Con. and other Hamilton fossils. On the underside of a sandstone stratum just above the creek are large numbers of the very mucronate form of Spirifer mucronatus (Con.) Bill. associated with Chonetes coronatus Con. The fossils and the stratigraphic position of the zone show that it is in the Hamilton formation. The species listed below were collected at this locality:

1 Spirifer granulosus *Con.* r
2 S. mucronatus (*Con.*) *Bill.* r
3 Tropidoleptus carinatus (*Con.*) *Hall* rr
4 Camarotoechia prolifica (*Hall*) *H. & C.* c
5 Nyassa arguta *Hall* r
6 Orthonota undulata *Con.* rr
7 Chonetes coronatus (*Con.*) *Hall* c

Above the rocky gorge just described, well toward West Fulton, Panther creek flows in a deep gorge, but the sides are covered with drift, clay and boulders of all sizes so that the bed rocks are concealed. At the three corners, perhaps 1½ miles below West Fulton, the section leaves the valley of Panther creek and follows the highway turning westerly, which ascends the steep hill that rises to the south of the creek valley. The road corners, by the barometer, are some 190 feet higher than the glen at X^2 and the slope of the hill for over 800 feet is pretty generally covered by drift. There are a few exposures along the highway in this 800 feet of elevation, as for example (X^4) 145 feet above the corners where fine, bluish, argillaceous shales and somewhat greenish sandstones occur. Again, 550 feet higher, toward the top of the hill and west of the first road turning to the south, is a ledge of rather coarse grained somewhat greenish gray sandstone (X^5) which has been referred to the Sherburne formation. About 145 feet higher, or by the barometer some 1280 feet above the level of the Schoharie river at the bridge below Breakabeen, are the bluish, argillaceous shales of X^6. This locality is well toward the summit of this part of the plateau and is to the west of the second

road turning to the south. It is an important outcrop, for some of the thin layers of the bluish shales contain abundant specimens of a few species of fossils. Spirifer mesastrialis Hall is a common species and this zone is in the Ithaca formation which covers the high part of the plateau to the south of Panther creek and west of the Schoharie river in the southern part of Fulton township. In coarser shales above the bluish ones the fossils are not so common. The following species were collected in a few minutes and a thorough search would undoubtedly materially increase the number.

1 Spirifer mucronatus (*Con.*) *Bill.* a
2 S. mesastrialis *Hall* c
3 Orthonota undulata *Con.* c
4 Sphenotus truncatus (*Con.*) *Hall* a
5 Schizodus appressus (*Con.*) *Hall* rr
6 S. *cf.* ellipticus *Hall* r
7 Grammysia (Sphenomya) cuneata *Hall* (?) r
Specimens broken and imperfectly preserved.
8 Palaeoneilo *cf.* plana *Hall* rr
9 Liopteria bigsbyi *Hall* r
10 Athyris spiriferoides (*Eaton*) *Hall* rr
11 Orbiculoidea *cf.* media (*Hall*) *H. & C.* r
The pedicle passage seems to be wider than in the figures of this species and scarcely connected at margin.

About 45 feet higher, lacking but 10 feet of the summit on the highway or approximately 1335 feet above the level of the Schoharie river, is a coarse grained somewhat greenish gray sandstone (X^7). On the next ridge to the west, at the same level as X^7, is another outcrop of the coarse grained, massive sandstone on which glacial striae are well preserved, their direction being from the n. e. toward the s. w.

16 Section up Panther creek from West Fulton to its head in the western part of Fulton township and then to the summit of the divide in the eastern part of Summit township

Prosser, Section C

Rather more than one half mile west of the village is a small quarry on the northern side of the highway which has furnished a part of the foundation stone used in West Fulton and there are also layers of blue flagging stone of fair quality. Some of the rather irregular sandstones contain numerous specimens of Spirifer granulosus (Con.) H. & C. associated with other Hamilton species. The quarry's elevation above Panther creek at West Fulton was not determined, but it is clearly several hundred feet below the top of the Hamilton formation in the lower part of the zone called C^1 of this section.

Three and one fourth miles w. n. w. of West Fulton in school district no. 7 the main branch of Panther creek turns sharply to the north; but the section follows the highway toward Summit and the smaller branch of the creek up the hill to the west. Some 490 feet higher than West Fulton, on the south side of the road after crossing the west branch of Panther creek and passing the road on which the schoolhouse is located, are quite thin, bluish, argillaceous shales (C[2]) certain layers of which contain abundant specimens of the very mucronate form of Spirifer mucronatus (Con.) Bill, associated with Chonetes coronatus (Con.) Hall. These shales are clearly in the Hamilton formation. The following species were collected:

1 Chonetes coronatus (*Con.*) *Hall* a
2 Spirifer mucronatus (*Con.*) *Bill.* a
3 Cyrtina hamiltonensis *Hall* rr
4 Camarotoechia congregata (*Con.*) *H. & C.* rr
5 Macrodon hamiltoniae *Hall* (?) rr
Imperfectly preserved.
6 Orthonota undulata *Con.* rr
7 Prothyris lanceolata *Hall* rr

For 50 feet the hillside is covered, when another outcrop of coarser and more arenaceous shales (C[3]) are reached which also contain abundant Hamilton fossils. The shales are capped by very thin bedded, even sandstones and the zone is clearly in the Hamilton.

1 Spirifer granulosus (*Con.*) *H. & C.* rr
2 S. audaculus (*Con.*) *H. & C.* c
3 Camarotoechia congregata (*Con.*) *H. & C.* c
4 Pterinea flabellum (*Con.*) *Hall* rr
5 Liopteria bigsbyi *Hall* (?) r
Broken and poorly preserved.

On the hillside 55 feet above C[3], or approximately 595 feet higher than West Fulton, are thin, bluish gray sandstones (C[4]) in which a few fossils occur. This ledge is about on a level with the small cemetery on the north side of the road, and is apparently in the Hamilton formation. 40 feet higher is a ledge of thin bedded, bluish gray sandstone five feet in thickness. A little below this stratum are loose fossils which seem to have come from this outcrop and apparently show its Hamilton age. At the edge of the woods on the south side of the road are ledges of rather coarse grained, thin bedded, grayish sandstone (C[5]). There are from 15 to 20 feet of these sandstones exposed, which apparently occur on the north side of the road at a little higher elevation. No fossils were found except plant stems; but there are numerous clay pebbles in some of the layers. This zone is probably near the dividing line between the Hamilton and Sherburne formations and it is a matter of some uncertainty to which formation

it should be referred. On the highway 50 feet higher or 825 feet above West Fulton are bluish to greenish argillaceous shales (C^6) and bluish gray flagging stone. No fossils were found and in lithologic characters these rocks closely resemble those of the Sherburne formation to which they are referred. Just south of the turn on the first road turning south toward Eminence are thin bedded, bluish gray, flagging stones (C^7) below which are smooth, bluish, argillaceous shales weathering to an olive tint and containing some concretionary nodules. These shales are about 45 feet above those of C^6.

On the highway 1¼ miles east of Summit, in the eastern part of Summit township, on the divide, is a layer of rather irregular sandstone (C^8) which contains a few fossils. There are also fossils in bluish, argillaceous shales occurring just above the sandstone. On each side of the summit 20 feet below the fossiliferous sandstone are smooth, bluish shales which weather olive and some grayish green flagging stone in which fossils were not found. This fossiliferous zone is regarded as indicating the appearance of the Ithaca fauna, succeeding the barren sandstones and shales of the Sherburne formations and it is referred to the Ithaca formation although the hasty search for fossils did not yield specimens of Spirifer mesastrialis Hall. The list of fossils is as follows:

1 Spirifer mucronatus (*Con.*) *Bill.* c
2 S. tullius *Hall* r
3 Tropidoleptus carinatus (*Con.*) *Hall* r
4 Microdon (Cypricardella) bellistriatus *Con.* rr
5 M. (C.) gregarius *Hall* rr
6 Sphenotus cuneatus (*Con.*) *Hall* rr
7 Schizodus appressus (*Con.*) *Hall* rr

On the south side of the road farther east near the Summit-Fulton township line along the upper course of one of the branches of the Westkill are coarse, grayish sandstone and thinner blue shales (C^8). This ledge is 140 feet lower than the fossiliferous zone of C^8 and is probably near the top of the Hamilton. Fossils occur rather sparingly, the three following species having been collected during a few minutes' search:

1 Tropidoleptus carinatus (*Con.*) *Hall* r
2 Spirifer sp. rr
Fragments
3 Nuculites oblongatus *Con.* rr
Large specimen—35 mm long and 19 high

On the western side of the divide going down into the second valley, sandstone and coarse shales containing abundant Hamilton fossils were found 120 feet below the zone C^8. Between the two fossiliferous zones are exposures of sandstones and smooth

bluish to olive shales which closely resemble, lithologically, those of the typical Sherburne formation. To the north of the road and northeast of Summit is a high rounded hill, known as Cobble hill, on which are plenty of these fine shales, the Sherburne formation apparently capping the hill.

The section described above may be represented diagrammatically in the following manner.

Summary of section up Panther creek from West Fulton to the divide west of West Fulton

950′		Divide on road 1¼ miles east of Summit
945′		C^8 Shales and sandstones containing fossils Ithaca
	75′	
870′		C^7 Bluish to olive shales and sandstones on Eminence road
	45′	
825′		C^6 Greenish shale and thin bedded sandstone Sherburne
	50′	
775′		
	20′	C^5 Thin bedded, grayish sandstone
755′		
	115′	Covered
640′	5′	Bluish gray sandstone; loose fossils Hamilton
635′		
	40′	C^4
595′		Thin sandstones with a few fossils
	55′	
540′		C^3 Coarser Hamilton shales
	50′	
490′		C^2 Fine Hamilton shales
	490′	C^1
		Quarry ½ mile west of West Fulton Hamilton
0′		Panther creek at West Fulton

17 Section of Devonian rocks made in the Catskill mountains at Palenville; Kaaterskill creek, New York

By Mr Andrew Sherwood in 1874[1]

Round Top of the Catskill mountains

152	SS. coarse, gray sandstone	440
151	Concealed	48
150	SS. coarse, gray	16
149	Concealed	130
148	SS. coarse, gray	32
147	Concealed	53
146	SS. coarse, gray, with many pebbles scattered through it	200
145	Shaly rock, red	27
144	Concealed	37
143	SS. coarse, gray; scattered pebbles	23
142	Concealed	340
141	SS. coarse gray	19
140	Concealed	20
139	Shaly rock, red	50
138	Concealed	15
137	SS. coarse, gray	83
136	Shaly rock, red	14
135	SS. coarse, gray	35
134	Shaly rock, red	2
133	SS. coarse, gray	5
132	Concealed	50
131	Conglomerate, coarse	16
130	SS. reddish	10
129	Shaly rock, red	11
128	SS. coarse, gray	63
127	Conglomerate, coarse	152
126	Shaly rock, red	47
125	SS. coarse, gray; pebbles	88
124	Shaly rock, red	37
123	SS. coarse, gray; scattered pebbles	38
122	Concealed	480
121	SS. coarse, gray	29
120	Concealed	219
119	SS. coarse, dark gray	15
118	Shaly rock, red	22
117	Concealed	60
116	SS. coarse, dark gray	12
115	Concealed	140
114	SS. gray, reddish towards the top	40
113	SS. red and gray; beds of red shaly rock	103
112	Shaly rock, red	103
111	SS. gray; fish bone bed 1 foot near the bottom of the 103 ft	8

[1] Am. Phil. Soc. Proc. 1877. 17:346–49.

110	Shale greenish and dark blue (some fish bones)	4
109	SS. gray	20
108	Shaly rock, red	68
107	Fish bone bed, 6 to 8 inches	½
106	Shaly rock, red, mottled with green	1½
105	Fish bone bed, 6 to 12 inches	¾
104	Shaly rock, greenish	2
103	SS. bluish gray	6
102	Shaly rock, red, somewhat mottled green	7
101	Shaly rock, greenish	6
100	SS. bluish gray	9
99	Shale, greenish gray	3
98	Shaly rock, rubbly, variegated, considerable percentage of peroxid of iron	3
97	SS. bluish gray	47
96	Shales, red and green	6
95	Shaly rock, gray and greenish	10
94	Shaly rock, red and green	6
	SS. bluish and gray; of great thickness at the village of Palenville (Continued downwards in the following)	

18 Section along the Schoharie creek in Schoharie county, N. Y. between Gilboa and Middleburg, from the Catskill down to the upper Helderberg

By Andrew and Clark Sherwood[1]

(Continued from the above)

94	Red shaly rock. (This is supposed to be the same bed no. 94, which bottoms the Catskill section of 1874)	12
	Top of Manor Kill cataracts at Sawmill	
93	Bluish gray SS.	15
92	Gray shaly rock	10
91	Gray SS.	14
90	Gray shale	2
89	Gray shale SS.	15
88	Red shaly rock, with green bands	12
87	Thick bedded gray SS.	17
86	Thin bedded gray SS.	20
85	Thin bedded gray SS. with plants	9
84	Hard (false bedded, some of it) gray SS.	20
83	Gray SS.	54
82	Unknown to foot of cataracts	30
81	Gray SS.	25
80	Dark sandy shale	2
79	Gray SS. (at Gilboa) stumps, leaves, stems	8
78	Dark shale	6
77	Gray SS.	10

[1] *Loc. cit.*

76	Gray and bluish shale and shaly rock	14
75	Red and green mottled shale	4
74	Reddish hard SS.	2
73	Gray SS. (the top makes the Gilboa falls)	40
72	Gray SS.	40
71	Unknown	?
70	Hard gray SS. (with sharp s. w. dip)	40
69	Unknown	25
68	Gray SS.	20
67	Unknown	50
66	Coarse flaky gray SS. (Makes top of Little Manor Kill fall)	10
65	Unknown	36
64	Gray SS.	22
63	Gray shaly rock, fossils in upper part	27
62	Gray shaly SS.; top is conglomeratic, some fossils	17
61	Unknown	60
60	Gray flaky SS., fossil plants	16
59	Gray slate and SS.	24
58	Gray SS.	9
57	Unknown	10
56	Hard gray SS.	4
55	Gray and bluish shale, a few fossils	33
54	Gray SS.	8
53	Dark shale	9
52	Unknown	34
51	Gray SS.	?
50	Unknown	36
49	Gray, greenish shale, shaly rock, few fossils	30
48	Gray SS.	13
47	Greenish shale	15
46	Gray SS. (some false bedded)	14
45	Gray SS. and shaly rock	20
44	Greenish rubbly rock	4
43	Gray SS., false bedded (makes Patchen Hollow rapids)	15
42	Unknown	14
41	Massive gray SS., marked horizon	35
40	Dark shaly rock	21
39	Thin bed gray SS.	8
38	Unknown	20
37	Coarse gray SS.	28
36	Unknown	34
35	Gray SS. (part concretionary)	8
34	Unknown	42
33	Dark, and gray shaly rock (fossils, spirals towards top)	36
32	Unknown	50
31	Gray SS., dark shale in the upper part of it (makes top of the Wauhalla) some fossils	72
30	Dark shaly rock	23
29	Gray SS.	87
28	Dark shaly SS., few fossils	8

27	Gray SS.	8
26	Dark shale	4
25	Bluish gray SS.	6
24	Gray and dark sandy shaly rock	41
23	Unknown	44
22	Thin bed gray SS.; a little of it false bedded; some concretionary	50
21	Gray sandy shaly rock	48
20	Thin bed gray SS.	27
19	Gray concretionary rock	4
18	Gray shaly SS. (base of Wauhalla mountain)	183
17	Bluish gray SS.	20
16	Gray and dark bluish black shale ("Tow-path" road)	70
15	Bluish black and gray shaly rock	25
14	Unknown	16
13	Dark gray and blackish shaly rock, fossils lower part	23
12	Gray and dark blue shaly SS. (lower end of towpath road. Probably part of bed at top of Vroman's Nose)	29
11	Gray shaly SS.; top of Vroman's Nose, passes under water at lower end of towpath road (inclination 581 feet in 2 miles, making no allowance for fall of Schoharie creek)	49
10	Blackish shale	11
9	Gray shale and shaly SS.	28
8	Dark gray shale (Vroman's Nose), fossils most abundant in upper part	284
7	Unknown up to ledge on Vroman's Nose. Surface covered with dark gray shale. 10 feet of black shale is exposed by road cut half a mile west of Vroman's Nose; and supposed to come in this interval of 205 feet	205
6	Unknown in Middleburg village	100
5	Black shale	2
4	(Black shale?) judging by the surface	21
3	Black slate	2
2	Unknown	15
1	Helderberg limestone (Onondaga) ½ a mile below Middleburg, at gristmill (makes falls in the Schoharie)	

Chapter 6

CHARACTERISTIC SECTIONS IN THE HELDERBERGS

The following characteristic sections of well known localities in the Helderbergs are here added, partly for comparison with sections at Schoharie, and partly for the purpose of making this guide useful for a wider region than the Schoharie valley. This is possible because the strata involved scarcely vary in lithic composition and fossil contents over the region here covered. As before, extensive use has been made of published sections, specially those of Professor Prosser.

19 Section near Knox

Prosser

About 4 miles southwest of Altamont and 1½ miles northeast of Knox, at a locality known as "the Rocks" are interesting exposures of the Helderberg limestones and specially of the Oriskany sandstone. This is also an excellent place for collecting Oriskany fossils, and the formation forms the bed of the Altamont–Knox highway for some distance. The following section begins on the lower road at the Armstrong house, near the foot of the hill, and extends to its top. The section is here given in descending order.

	Feet	Total
B^6 Onondaga light gray limestone capping the hill. The dip on the face of this ledge is 2° s. 38° w.		
B^5 Esopus shale, largely covered on the slope to the south of the road but showing fairly well in small gullies. One fourth of a mile to the east is a small quarry in the lower part of the shale[1]	83	245
B^4 Very fossiliferous Oriskany sandstone underlying the road. On top of the sandstone, along the road are large numbers of impressions of S p i r o p h y t o n c a u d a g a l l i	2	162
B^3 Becraft limestone but a little below the Altamont–Knox road	10	160

[1]This thickness is probably too small due to the considerable horizontal distance and strong southerly dip. C. S. P.

	Feet	Total
B² Mostly covered slope, with occasional exposures of shaly limestone [New Scotland.] These shales are very fossiliferous, and many species may be obtained in some of the small gullies, where the following were collected..........		95–160

1 Spirifer macropleura (*Conrad*) *Castelnau* a[1]
2 S. perlamellosus (*Hall*) c
3 S. cyclopterus *Hall* a
4 Eatonia medialis (*Vanuxem*) *Hall* c
5 Leptaena rhomboidalis (*Wilckens*) *H. & C.* c
6 Stropheodonta becki *Hall* rr
7 Strophonella punctulifera (*Con.*) *Hall* r
8 S. cavumbona (*Hall*) *H. & C.* rr
9 Meristella laevis (*Van.*) *Whitfield* a
10 Trematospira globosa *Hall* r
11 T. multistriata *Hall* rr
12 Dalmanella planoconvexa (*Hall*) *H. & C.* a
13 D. subcarinata (*Hall*) *H. & C.* c
14 D. perelegans (*Hall*) *H. & C.* rr
15 Rhipidomella oblata (*Hall*) *H. & C.* r
16 Atrypa reticularis (*Lin.*) *Dal.* rr
17 Uncinulus vellicatus (*Hall*) *H. & C.* rr
18 Stenoschisma formosum *Hall* rr
19 Lingula centrilineata *Hall* rr
20 Platyceras ventricosum *Con.* rr
21 Streptelasma strictum *Hall* rr

	Feet	Total
B¹ Massive ledges of Coeymans limestone. Probably the lower part of this zone is transitional to the Manlius limestone below; but the latter is not shown at this place..................		65–65

20 Altamont section

Prosser

The section is given in descending order

	Feet	Total
Oriskany. At the top of the second terrace, about $1\frac{3}{4}$ miles southwest of High Point, on the farm of Hiram Clickman, is a ledge of massive rock frequently exposed about the edge of the hill, composed of the Becraft limestone and Oriskany sandstone. The northern end of the hill was partly covered. The Oriskany sandstone is rather dark gray, weathering to a brownish color, quite calcareous, and contains many specimens of fossils. The thickness varies from $1\frac{3}{4}$ to 2 feet............	2	736

The following fossils were found in it:

1 Rensselaeria ovoides (*Eaton*) *Hall* c
2 Spirifer murchisoni *Cast.* c
3 S. arenosus (*Con.*) *Hall* c

[1] a = abundant, c = common, r = rare, rr = very rare.

4 Eatonia peculiaris (*Con.*) *Hall* r
5 Rhipidomella musculosa (*Hall*) *H. & C.* (?) r
6 Metaplasia pyxidata (*Hall*) *H. & C.* r
7 Hipparionyx proximus *Van.* r
8 Meristella lata (*Hall*) *H. & C.* rr

There are frequent exposures of this and the next lower formations along the highway running southeast to the Indian Ladder road, and at various places one or the other forms the bed of the road for a distance of several rods.

	Feet	Total
Becraft. Ten feet of the Becraft limestone was found, but it is probably somewhat thicker, and the Oriskany sandstone rests immediately on top. The contact is finely shown at several places in the woods at this locality, the sandstone resting on the massive limestone, so that there are no beds of shaly limestone [Port Ewen] between these formations, as at Schoharie and Howes Cave. The limestone is light gray and rather crystalline with the usual lithologic characters of the Becraft........	12±	-734

New Scotland. On the partly covered slope south and west of the Pentamerus [Coeymans] terrace are occasional ledges of the thicker layers of the shaly limestone [New Scotland beds] and outcrops of the very much weathered and decomposed calcareous shales. These shales contain abundant fossils, and frequently on the surface of the slope many nearly perfect shells may be found. A hasty collection from such an exposure gave the following species:

1 Spirifer macropleura (*Con.*) *Castelnau* c
2 S. perlamellosus *Hall* c
3 S. cyclopterus *Hall* c
4 Trematospira multistriata *Hall* r
5 T. globosa *Hall* rr
6 Leptaena rhomboidalis (*Wilckens*) *H. & C.* c
7 Eatonia medialis (*Van.*) *Hall* a
8 E. singularis (*Van.*) *Hall* rr
9 Meristella laevis (*Van.*) *Whitfield* a
10 Orthis (Dalmanella) subcarinata *Hall* r
11 O. (D.) perelegans *Hall* rr
12 O. (D.) planoconvexa *Hall* r
13 Orthothetes woolworthanus (*Hall*) *H. & C.* rr
14 Stropheodonta punctulifera (*Con.*) *Hall* rr
15 Lingula centrilineata *Hall* rr
16 Uncinulus campbellanus *Hall* rr
17 U. vellicatus *Hall* rr
18 U. nucleolatus *Hall* rr
19 Platyceras tenuiliratum *Hall* rr
20 P. gibbosum *Hall* rr
21 Streptelasma strictum *Hall* rr
22 Monotrypella colliculata *Hall* rr
23 Favosites conicus *Hall* rr
24 Favosites helderbergiae *Hall* r

	Feet	Total
Coeymans. At the top of the High Point cliff there are 27 feet of Pentamerus [Coeymans] limestone, and a little to the south 10 feet more is shown. This limestone forms the top of the terrace, which extends nearly one mile to the south of the cliff before the shaly limestone [New Scotland] is reached, but, on account of the heavy dip, it is not possible to give its entire thickness..............	37	722
Manlius. The lower part of the cliff is composed mainly of thin bedded, dark blue limestones, having the metallic ring of those composing the Tentaculite [Manlius] formation, and in the lower part are abundant specimens of Tentaculites gyracanthus (Eaton) Hall. By the side of the High Point path there is 38 feet of this rather thin bedded limestone, in all of which Spirifer vanuxemi Hall is common, even to the top. The Tentaculites was not found in these upper layers. At this horizon there is a lithologic change; the upper beds are more massive, breaking with an irregular fracture, and Pentamerus [Sieberella] galeatus (Dal.) Hall occurs near their base, so that the line of division between the Tentaculite [Manlius] and Pentamerus [Coeymans] limestones was considered to be represented here	38	685

The fossils found in this were:

1 Tentaculites gyracanthus (*Eaton*) *Hall* aa
2 Spirifer vanuxemi *Hall* a
3 Leperditia alta (*Con.*) *Hall* r
4 Modiolopsis dubia *Hall* rr
5 (?) Tellinomya nucleiformis *Hall* rr
6 Stropheodonta varistriata (*Con.*) *Hall* r
7 Chaetetes (Monotrypella) arbusculus *Hall* c

	Feet	Total
Rondout. In places at the base of the cliff 1 to 1½ feet of dark gray, impure, thin bedded limestone is exposed, which resembles the upper layers of the waterlime at Schoharie and Howes Cave, to which formation it is referred........................	1	647

Stratigraphic unconformity

Lorraine beds. To the south of Altamont is a conspicuous point of the Helderbergs known as High Point, where the general trend of the escarpment turns from a northwesterly to a westerly direction. The lower 646 feet of the point, according to the

	Feet	Total
measurement of Ashburner[1] from the Delaware and Hudson Railroad station to the base of the Rondout waterlime belong in the Lorraine beds. This thickness, added to the 2880 feet of shales and thin sandstones passed through in the Altamont well before reaching the top of the Trenton limestone, gives a thickness of 3475 feet for the Lorraine and Utica formations at this locality. Along the small brook in which the gas well is located there are exposures of the Lorraine beds, consisting of bluish to grayish argillaceous shales, with an occasional sandstone stratum; but the upper part of the zone is covered around the slope of High Point..................................	646–	646

About 3½ miles southwest of Altamont, on the road from Altamont to Knox, is a conspicuous ledge of the Pentamerus [Coeymans] limestone . . . to the east of the road, which at this locality is very fossiliferous, and the weathering and fires have so decomposed parts of the massive cliff that it makes an excellent place for collecting. Along the road from Altamont there are alternating exposures of sandstones and shales, sandstones predominating, with a thickness of 635 feet by the barometer without allowing for the dip, which would increase the amount; then 210 feet are covered when this Pentamerus [Coeymans] ledge is reached, 845 feet higher than Altamont. It is not clear whether the base of the Pentamerus [Coeymans] is shown or not, but the Tentaculite [Manlius] is covered, and only 30 feet of the Pentamerus [Coeymans] is exposed. The following species were collected at this place.

1 Sieberella galeata (*Dal.*) *H. & C.* aa
2 Atrypa reticularis (*Lin.*) *Dal.* a
3 Strophonella punctulifera (*Con.*) *Hall* c
4 Stropheodonta varistriata (*Con.*) *Hall* r
5 Spirifer perlamellosus *Hall* r
6 Uncinulus mutabilis (*Hall*) *H. & C.* r
7 U. pyramidatus (*Hall*) *H. & C.* rr

21 Indian Ladder section

Prosser

Near the northern end of the Helderberg mountains, about south of Meadowdale, on the Susquehanna division of the Delaware and Hudson railroad, is the highway known as the Indian

[1] The railroad station (formerly Knowersville) is 459 feet A. T., and Ashburner gave the altitude of the gas well's mouth as 510 A. T., and the base of the Lower Helderberg limestones as 595 feet vertically above the mouth of the well [Am. Inst. Min. Eng. Trans. 16:951].

Ladder road and the only one climbing these precipitous cliffs between New Salem and Altamont. The Tentaculite [Manlius] and Pentamerus [Coeymans] limestones form the prominent cliff which extends from New Salem around the northern end of the mountains to Altamont; but on the higher terraces and hills to the south the later formations are found, and their distribution is shown on the "Preliminary Geologic map of Albany County, N. Y.", by N. H. Darton.[1] Along the Indian Ladder road are exposures of the upper part of the Lorraine beds, with magnificent cliffs of Tentaculite [Manlius] and Pentamerus [Coeymans] limestones; while to the east and south the succeeding hills show the later formations up to the lower part of the Hamilton, which forms the upper part of Signal station hill.[2] The section from Meadowdale to the top of Signal station hill is as follows [in descending order]:

	Feet	Total
Hamilton; arenaceous shales to thin sandstones at the base; but mainly shales to the top of Signal Station hill. Some specimens of the small Hamilton lamellibranchs, as Palaeoneilo constricta (Con.) Hall; Nucula bellistriata (Con.) Hall; Nuculites triqueter Con.; N. oblongatus Con. and others, are found in the shales in the upper part of this hill. Exposed	130	1495
Covered	20	1365
Marcellus shale; black argillaceous shales exposed along the road up the hill to the south of the New Salem road and in the gullies on the northwestern side of the hill..................................	170	1345
Onondaga limestone; well shown in the upper part of the terrace to the north of the New Salem road. The upper part of the formation forms the floor of this road for nearly two miles on the plateau..	98	1175
Schoharie grit; shown on a south road at the base of the light gray Onondaga limestone...........	3½	1077
Esopus shale; finely exposed along the road to the east of the brook and house. Another excellent exposure occurs in the glen to the east of the eastern north and south road which on the plateau connects the Indian Ladder and New Salem roads	100	1073½

[1] N. Y. State Geol. 15th An. Rep't. 1895.
[2] The station was called Helderberg and is 1823 feet A. T. (Final results of the Triangulation of the N. Y. State Survey. 1887, p. iii).

	Feet	Total
Oriskany sandstone occurs in the woods on top of the hill south of Indian Ladder cliff, where there are numerous weathered blocks. Again it is well shown to the east of this hill on the ridge west of the house and brook mentioned above. Its thickness in these outcrops varies from 1 foot to 1 foot, 4 inches	1–973½	

Above the house on the eastern side of the brook the top of the Becraft limestone, capped by the Oriskany sandstone, is well shown. The shaly limestone may also be seen to excellent advantage along the banks of Black creek to the north of the Indian Ladder road.

	Feet	Total
New Scotland and Becraft. Largely covered slope to the south of the cliff and east of the stream and road. In the field are various outcrops of the thicker beds of the [New Scotland] shaly limestone, and in the edge of the woods the top of Becraft limestone is shown. Much better outcrops of the shaly limestone, however, occur to the east of these woods in the field and along the western bank of a small stream furnishing an excellent collecting place. The following species were obtained at this locality.............	160–972½	

1 Spirifer macropleura (*Con.*) *Cast.* c
2 S. perlamellosus *Hall* c
3 S. cyclopterus *Hall* a
4 Leptaena rhomboidalis (*Wilckens*) *H. & C.* c
5 Strophonella cavumbona (*Hall*) *H. & C.* rr
6 Orthothetes woolworthanus (*Hall*) *H. & C.* rr
7 Meristella laevis (*Van.*) *Whitfield* c
8 Nucleospira ventricosa *Hall* r
9 Parazyga deweyi (*Hall*) *H. & C.* rr
10 Trematospira globosa *Hall* r
11 Uncinulus vellicatus (*Hall*) *H. & C.* r
12 Rhipidomella oblata (*Hall*) *H. & C.* r
13 Cypricardinia lamellosa *Hall* rr
14 Platyceras ventricosum *Con.* rr
15 P. retrorsum *Hall* (?) rr
16 Dalmanites pleuroptyx (*Green*) rr
17 Favosites conicus *Hall* rr
18 F. sphaericus *Hall* rr
19 Streptelasma strictum *Hall* rr

Coeymans limestone; the massive strata forming the upper part of the vertical cliff. Beautifully shown in the cliff on the western side of the road . . . The measurements along this cliff vary from 49 to 52 feet for the thickness of the Pentamerus [Coeymans]	52–812½	

	Feet	Total
Transitional beds from the Manlius to the Coeymans. Tentaculites gyracanthus Eaton has not been noticed in this zone, which is a little below the middle of the cliff, but Spirifer vanuxemi Hall reaches well toward its top...	14½	760½
Manlius; thin bedded limestone, forming lower part of vertical cliff. Some of the layers contain immense numbers of Tentaculites gyracanthus Eaton	31½	746
Rondout waterlime (?); best exposure near the base of the cliff at the waterfall. The measurements of different parts of the zone vary from 3¾ to 4¾ feet[1]	4½	714½
Stratigraphic unconformity		
Lorraine beds. Partly covered; shales and thin sandstones of the Hudson river beds exposed along the road. At the top a massive sandstone 30 or more feet in thickness shown at the base of the cliff to the east of the road, which may be called the Indian Ladder cliff, at the waterfall. Mr Walcott reported "About 300 feet of the Hudson" in this section, and found specimens of Orthis testudinaria and Trinucleus concentricus.[2]..................	400	710
Lower Hudson river beds. Covered from the station to a point near the base of the steep part of the hill on the Indian Ladder road.................	310	310

22 Section of Countryman hill, near New Salem

Prosser and Rowe, fig. 202

The following section begins at the foot of the steep cliff a little north of west of New Salem and continues to the top of the hill. It is given in descending order.

	Feet	Total
Hamilton and Marcellus.........................	425	1247
Top of Countryman hill composed of rather arenaceous shales that contain very few fossils. On the top are loose glacial boulders of Corniferous [Onondaga] limestone. Near the base of this upper ridge are fine, argillaceous shales of		

[1] This zone consists partly of pyritiferous shales which lithologically differ from the waterlime and Professor Harris compares them with the Brayman (Salina) shales below the Cobleskill limestone at Howes Cave (Bul. Am. Pal. no. 19, p. 25) C. S. P. These beds represent the basal layer of an overlapping series. A. W. G.

[2] Geol. Soc. Am. Bul. 1890, 1:345.

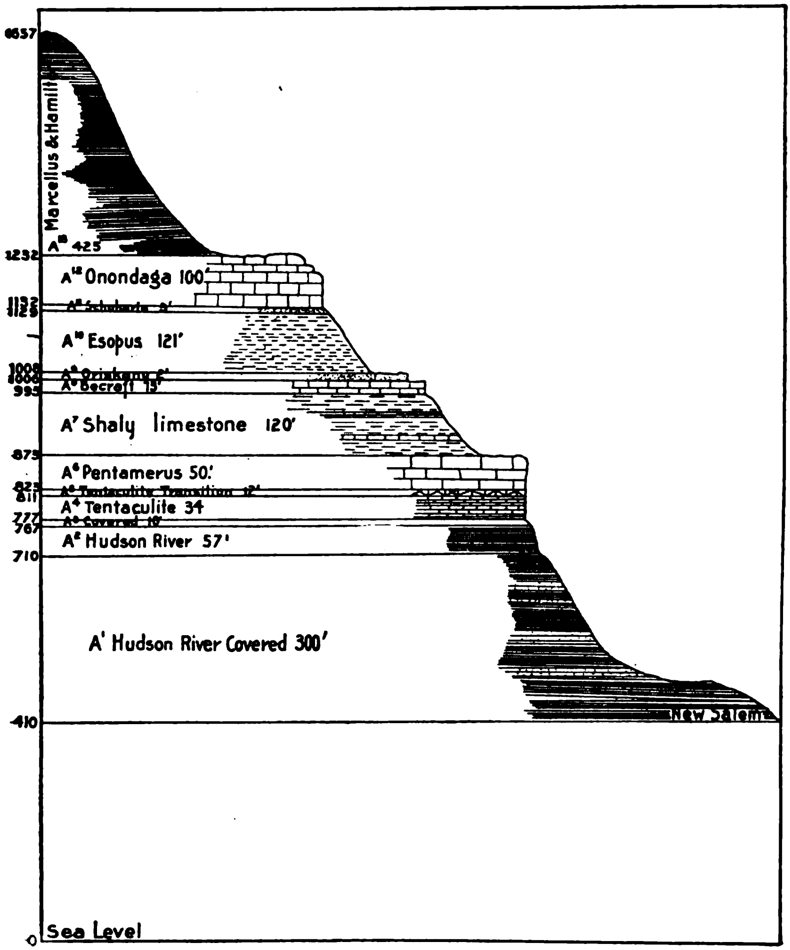


Fig. 202 Section of Countryman hill. (After Prosser)

the Marcellus shown in small draws, but the greater part of the slope is covered by soil so that it is impossible to determine the line of division between the Marcellus and Hamilton formations. Again in the Helderberg region there is a gradual change in the lithologic characters from the Marcellus to the Hamilton, and the Marcellus shales have a greater thickness than in central and western New York. It is probable that the upper part of the hill belongs in the Hamilton formation. To the southwest across one of the head branches of the Onis-

	Feet	Total
kethau creek is the highest ridge of the Helderbergs which is composed of slightly arenaceous shales containing abundant Hamilton fossils.		
Onondaga limestone..............................	100–822	
Cliff of massive limestone, the top of which forms the upper terrace due to the erosion of the Marcellus shale. The rock is light gray in color, contains in places a considerable amount of chert and is not very fossiliferous, most of the species being corals.		
Schoharie grit..................................	3–722	
An impure, dark gray limestone which weathers to a buff, porous sandrock, shown in places at the base of the Onondaga limestone on the cliff south of west of the house of Mr K. P. Parrish, where a thickness of 2′ 10″ was measured.		
Esopus shales..................................	121–719	
Blackish, somewhat arenaceous shales which contain specimens of Spirophyton caudagalli (Van.) Hall.		
Oriskany sandstone	2–598	
Very dark gray quartzite sandstone which weathers to a brownish color and contains abundant fossils. The upper surface of this sandstone is generally covered with markings of Spirophyton caudagalli, and it forms the upper part of the lower terrace. The fossils are:		

1 Spirifer arenosus (*Con.*) *Hall* a
2 S. murchisoni *Cast.* a
3 S. pyxidatus *Hall* r
4 Rensselaeria ovoides (*Eaton*) *Hall* c
5 Eatonia peculiaris (*Con.*) *Hall* c
6 Meristella lata *Hall* r
7 Leptocoelia flabellites (*Con.*) *Hall* r
8 Orthis (Rhipidomella) musculosa *Hall* c
9 Hipparionyx proximus (*Van.*) *H. & C.* (?) r
Small specimens, probably young individuals.
10 Platyostoma ventricosum *Con.* r
11 Orbiculoidea ampla (*Hall*)=Discina grandis (*Hall*) *H. & C.* r
12 Orthis *sp.* r
13 Stropheodonta *cf.* magniventra *Hall* r
14 Platyceras nodosum *Con.* r

Becraft limestone[1]	17–596	
Ledge of massive, light gray, fossiliferous limestone which is well exposed some distance		

[1] Corrected measurements for this and the New Scotland beds were given by Prosser in Am. Geol. 1903. 32:380.

above the highway in the vicinity of the house of Mr K. P. Parrish. The fossils are:

1 Spirifer concinnus *Hall* a
2 Sieberella pseudogaleata (*Hall*) *H. & C.*= Pentamerus pseudogaleatus *Hall* a
3 Atrypa reticularis (*Linn.*) *Dal.* a
4 Wilsonia ventricosa (*Hall*) *H. & C.*= Rhynchonella ventricosa *Hall* r
5 Rhynchonella (Uncinulus) nobilis *Hall* c
6 (Uncinulus) campbellanus *Hall* r
7 Orthis (Schizophoria) multistriata *Hall* c
8 O. (Rhipidomella) oblata *Hall* r
9 Spirifer cyclopterus *Hall* (?) r
10 Leptaena rhomboidalis (*Wilckens*) *H. & C.* r
11 Orthothetes cf. woolworthanus (*Hall*) *H. & C.* r
12 Aspidocrinus scutelliformis *Hall* a
13 Lichenalia torta *Hall* r
14 Streptelasma strictum *Hall* r
15 Favosites sphaericus *Hall* r
16 Bryozoa *sp.*

	Feet	Total
New Scotland beds................................	116	–579

Grayish calcareous shales and shaly limestones. The shales contain great numbers of fossils many of which are nicely preserved. This formation constitutes the lower part of the first terrace to the west of New Salem and has the most gentle slope of any of the formations composing this part of the hill until the talus at its base is reached. The fossils are:

1 Stropheodonta (Leptostrophia) becki *Hall* c
2 Spirifer perlamellosus *Hall* a
3 Leptaena rhomboidalis (*Wilckens*) *H. & C.* a
4 Trematospira globosa *Hall* c
5 Spirifer cyclopterus *Hall* c
6 S. macropleura (*Con.*) *Hall* c
7 Stenoschisma formosum (*Hall*) *H. & C.*= Rhynchonella formosa *H.* r
8 Atrypa reticularis (*Linn.*) *Dal.* r
9 Meristella arcuata *Hall* r
10 Orthis (Dalmanella) planoconvexa (*Hall*) *H. & C.* r
11 Nucleospira ventricosa *Hall* r
12 Strophonella punctulifera (*Con.*) *H. & C.* c

Some of these specimens seem to be the species called S. cavumbona H.; but it is said to be identical with S. punctilifera (*Con.*) *H. & C.*, in *Paleontology of New York*, v. 8, pt 1, p. 291.

13 Tentaculites elongatus *Hall* r
14 Streptelasma strictum *Hall* r
15 Fenestella *sp.* c
16 Dalmanites pleuroptyx (*Green*) *Hall* r
17 Crinoid segments
18 Uncinulus vellicatus (*Hall*) *H. & C.*= Rhynchonella vellicata *Hall* r
19 Lichenalia torta *Hall* r
20 Uncinulus abruptus (*Hall*) *H. & C.*= Rhynchonella abrupta *Hall* r
21 Favosites sphaericus *Hall* r
22 Eatonia medialis (*Van.*) *Hall* r
23 Rhynchonella transversa *Hall* (?) r
24 Orthoceras *sp.*
25 Trematospira multistriata *Hall* r
26 Avicula tenuilamellata *Hall* (?) r

	Feet	Total
Coeymans limestone		50–463
Massive, bluish gray limestone forming the upper part of the conspicuous cliff to the west of New Salem. This limestone forms the upper part of the prominent cliff which may be followed from southwest of New Salem around the northeastern and northern ends of the Helderbergs to Altamont.[1] The fossils are:		

1 Sieberella galeata (*Dal.*) *H. & C.*= Pentamerus galeatus *Hall* a
2 Uncinulus mutabilis (*Hall*) *H. & C.*
3 Atrypa reticularis (*Linn.*) *Dal.*

[1]Professor Harris has recently given the thickness of the Coeymans limestone on Countryman hill as 32 feet [Am. Pal. Bul. 19, p. 26] and that of the Manlius limestone in the neighborhood of the Indian Ladder as 63.7 feet [*ibid.*, pl. 1, fig. 8]. The total thickness for the two formations in Professor Harris's section is 95.7 feet and in mine 96 feet, which shows that there is scarcely any difference in the sections except that Professor Harris drew the line of separation between the Manlius and Coeymans limestones at a higher horizon than I did between the transitional Tentaculite and Pentamerus limestones. In my Helderberg sections it was attempted to divide this part of the limestones into the Tentaculite and Pentamerus as originally classified by Gebhard [*see* Mather. Geol. N. Y. 1st Dist. 1840, p. 237, 238]. It was called Tentaculite limestone as high as Tentaculites gyracanthus, Spirifer vanuxemi or Leperditia alta occur and then the first lithologic break above was considered the base of the Pentamerus limestone. It is probable, however, that according to this delimitation the top of the Tentaculite limestone is not synchronous with the top of Vanuxem's "Manlius water lime group" [*ibid.*, Geol. N. Y. 3d Dist. p. 376. This formation was vaguely defined by Vanuxem in his Third An. Rep't. 1839, p. 272 under the heading "Water Lime" as "the water lime group of Manlius"], and after an examination of the typical Manlius section I incline to the opinion that the top of the Manlius limestone is stratigraphically higher than what was considered the top of Gebhard's Tentaculite limestone of the Helderbergs. In his final report Mather stated that "The Pentamerus limestone is a mass of rock some fifty feet in thickness" which "forms a continuous stratum from the west line of Schoharie county eastward to the Helderberg mountains in Berne and Bethlehem." [Geol. N. Y. pt I, 1843, p. 347] and in a general way Mather's description and thickness were accepted by me in delimiting the Pentamerus limestone. Mather, however, did not clearly state the thickness of the Tentaculite limestone which he called the upper member of the "Water-lime group" and stated that "The *upper* part of the tentaculite limestone is a black and dark grey slaty compact (in some layers subcrystalline) limestone, in layers from an inch to a foot thick," while the middle part he gave as "composed of slaty black layers of compact limestone, containing an abundance of the Tentaculites ornatus [T. gyracanthus], Cytherina alta [Leperditia alta], Orthis plicata [Spirifer vanuxemi], and some of the Avicula rugosa. These are characteristic species" [*ibid.*, p. 350]. It was thought that in a general way the upper part of Mather's Tentaculite limestone corresponded with what I called the transitional Tentaculite; but perhaps it represents the zone which Professor Harris has indicated between the limestones containing the Tentaculite fauna and the overlying Coeymans or Helderbergian, in his sections from Manlius to the Helderbergs [*loc. cit.*, pl. 1, fig. 3–8]. *Charles S. Prosser*

	Feet Total
Transition beds	12–413
Thinner bedded limestones than the above which are transitional in lithologic and faunal characters from the Pentamerus [Coeymans] to the Tentaculite [Manlius] limestone.	
Manlius limestones	34–401
Dark blue, thin bedded limestones, the layers of which are generally from one to three inches in thickness and break with a ringing sound. These thin limestones form the lower part of the vertical cliff from New Salem around the northern end of the Helderbergs to Altamont. The fossils are:	

1 Tentaculites gyracanthus (*Eaton*) *Hall* aa
2 Spirifer vanuxemi *Hall* aa
3 Leperditia alta (*Con.*) *Hall* aa
4 Megambonia aviculoidea *Hall* r
5 Modiolopsis (?) dubia *Hall* r
6 Chaetetes (Monotrypella) arbusculus *Hall* r

Covered by soil and talus..........................	10–367
Lorraine beds	57–357
Bluish gray, fairly massive sandstones which alternate with dark colored argillaceous shales.	
Covered by soil, drift and talus to the foot of the hill	300–300

23 Section south of New Salem

Prosser and Rowe

In the above section the contact of the Lorraine beds and the overlying limestones is covered, but in a small glen west of the house of Rensselaer Markel ½ mile south of New Salem the contact is clearly shown. The section of this glen is as follows [descending order]:

	Feet Total
Coeymans (partly exposed)......................	38–180
Massive limestone forming cliff at the head of the run which is the southerly continuation of the lower cliff directly west of New Salem.	
Transitional	12½–142
Transitional layers from the Pentamerus [Coeymans] to the Tentaculite [Manlius] limestone, containing Spirifer vanuxemi Hall and Leperditia alta (Con.) Hall.	

	Feet	Total
Manlius	$32\frac{1}{2}$	$129\frac{1}{2}$
Thin bedded dark blue limestone.		
Rondout waterlime	$6\frac{1}{2}$	97
Drab, impure limestone, well exposed in the run at the foot of the cliff.		
Basal clastic beds of Rondout	$\frac{1}{2}$	$90\frac{1}{2}$
Greenish sandstone to coarse arenaceous shale containing plenty of iron pyrites, 10 inches in thickness.		
Stratigraphic unconformity		
Lorraine shales	90	90
Dark blue to olive tinted argillaceous shales well exposed in the steep banks of the brook.		

24 Clarksville and Oniskethau creek section

Prosser and Rowe, fig. 203.

This section begins about two miles east of Clarksville near Mr Bradford Allen's about one quarter of a mile north of the Delaware turnpike and ends at the top of Wolf hill nearly two miles west of the village. The section comprises in descending order:

	Feet	Total
Hamilton shales	490	1261
Brownish arenaceous shales and sandstones in upper part. The lower 200 feet or more of black arenaceous shales which weather to a brownish color, and brownish sandstones, are well exposed in the several gullies of Wolf hill. The upper part of the hill is mostly covered though here and there ledges may be seen. About 200 feet above the base of the formation fossils begin to appear in quite large numbers and at about 400 or 450 feet they become very abundant. The fossils are as follows:		

Found about 200 feet above base of Hamilton.

1 Lingula punctata *H.* (?) rr
2 Chonetes deflectus *H.* c
3 Newberria claypolii *H.* (?) rr
4 Pentamerella pavilionensis *H.* (?) rr
5 Camarotoechia congregata (*Con.*) *H. & C.* = Rhynchonella congregata (*Con.*) *H.* rr

Found over 400 feet above the base of Hamilton.

1 Spirifer acuminatus (*Con.*) *H.* a
2 S. mucronatus (*Con.*) *Bill.* c
3 Tropidoleptus carinatus (*Con.*) *H.* rr
4 Athyris spiriferoides (*Eaton*) *H.* rr
5 Chonetes deflectus *H.* c
6 Strophalosia *cf.* truncata (*Hall*) *H. & C.* r

7 Pterinea flabellum (*Con.*) *H.* r
8 Nyassa arguta *H.* aa
9 Leptodesma rogersi *H.* rr
10 Actinopteria subdecussata *H.* rr
11 Liopteria dekayi *H.* rr
12 L. bigsbyi *H.* rr
13 Palaeoneilo maxima (*Con.*) *H.* rr
14 P. constricta (*Con.*) *H.* r
15 Modiomorpha concentrica (*Con.*) *H.* rr
16 Tentaculites bellulus *H.* (?) rr

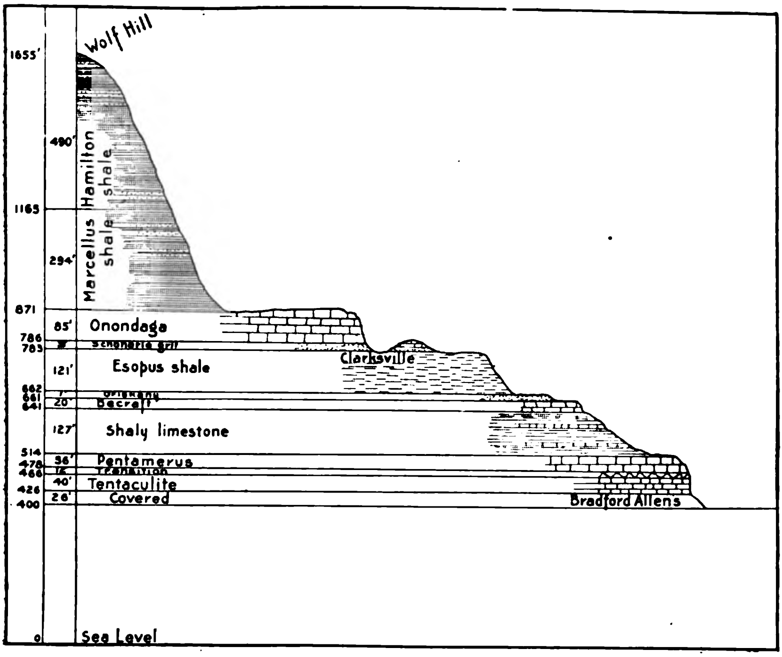


Fig. 203 Section of escarpment near Clarksville. (After Prosser)

	Feet	Total
Marcellus shales		300–771

Black argillaceous shales with dark slightly calcareous sandstones. In a gully in the rear of the house of Elias Mathias the upper 200 feet of this formation are well exposed as well as its gradual transition to the arenaceous shales of the Hamilton. The lower 100 feet or more of this formation are covered, after that there are about 80 feet of black, argillaceous shales, then about 30 feet of shales of this character interspersed frequently with layers of slightly calcareous, dark sandstone, above which are 85 feet of dark, argillaceous shales. It is rather

difficult to distinguish the line of division between this formation and the Hamilton. At the point where the division has been made the shales suddenly become more arenaceous in character though they still retain their black color, except that when exposed they weather brown. The fossils are:

1 Chonetes mucronatus *H.* a
2 Glyptocardia speciosa *H.* a
3 Coleolus tenuicinctum *H.* r
4 Goniatites discoideus *H.* c

	Feet	Total
Onondaga limestone	85–	471

A massive gray limestone in which large quantities of chert may be found in thin layers. According to the statement of Mr H. Ingraham, who drilled a well through this formation about a quarter of a mile south of Clarksville, the upper nine feet are entirely clear of chert, below this are 15 feet in which the chert is very abundant. In the lower part of the formation chert was encountered but in rather small quantities.

There is an outlier of this formation which forms the top of the ridge east of the village, and when the Oniskethau creek cut through this ridge the outlying area was cut off from the rest of the formation. This outlier was mentioned by Mr Darton who noted the infrequency of such outliers in this formation.[1] The measurement of this formation was taken at the foot of Bennett rather than Wolf hill, because the exposure there permitted it to be more accurately done. The fossils are:

1 Meristella unisulcata (*Con.*) *H.* r
2 Leptaena rhomboidalis (*Wilck.*) *H. & C.* r
3 Atrypa reticularis (*Lin.*) *Dal.* aa
4 A. spinosa *H.* aa
5 Pentamerella arata (*Con.*) *H.* c
6 Stropheodonta concava *H.* r
7 S. textilis *H.* rr
8 Spirifer duodenarius *H.* a
9 S. macrus *H.* (?) rr
10 Dalmanites (Coronura) aspectans (*Con.*) *H.* rr
11 Phacops cristata *var.* pipa *H.* rr
12 Platyceras dumosum *Con.* c
13 Cyrtoceras *sp.* rr
14 Zaphrentis gigantea (*LeSueur*) *Edw. & H.* rr
15 Z. corniculum (*LeSueur*) *Edw. & H.* rr
16 Fenestella biseriata *H.* rr

[1] N. Y. State Geol. 13th An. Rep't, p. 242.

	Feet	Total
Schoharie grit		3–386

A dark, impure limestone which weathers to a buff, porous sandstone. The erosion of the Onondaga limestone has left this formation well exposed at Clarksville both at the foot of the upper gorge and the top of the lower and fossils may easily be collected from it. Among the fossils found here are:

1 Strophonella ampla (*Hall*) *H. & C.* r
2 Atrypa reticularis (*Lin.*) *Dal.*= Atrypa impressa *H.* aa
3 Pentamerella arata (*Con.*) *H.* a
4 Meristella (Pentagonia) unisulcata (*Con.*) *H.* rr
5 M. nasuta (*Con.*) *H.* aa
6 Centronella glans-fagea *H.* r
7 Orthis (Rhipidomella) peloris *H.* (?) rr
8 O. (R.) alsus *H.* r
9 O. (Schizophoria) propinqua *H.* (?) rr
10 Spirifer raricosta (*Con.*) *H.* r
11 S. duodenarius *H.* rr
12 S. fimbriatus (*Con.*) *Bill.* rr
13 Orthothetes pandora (*Bill.*) *H. & C.* rr
14 Chonetes hemisphericus *H.* r
15 Cyrtina hamiltonensis *H.* rr
16 Stropheodonta perplana (*Con.*) *H.* rr
17 S. inaequiradiata *H.* rr
18 S. demissa (Con.) *H.* r
19 Coelospira camilla *H.* r
20 Amphigenia elongata (*Van.*) *H.* rr
21 Cypricardinia planulata (*Con.*) *H.* r
22 Conocardium cuneus (*Con.*) *S. A. Miller* c
23 Phacops cristata *H.* r
24 Dalmanites anchiops (*Green*) *H.* r
25 Orthoceras zeus *H.* (?) rr
26 O. *sp.* c
27 Cyrtoceras *cf.* eugenium *H.* rr
28 Zaphrentis *sp.* a
External impression.
29 Streptelasma *sp.* c
External impression.

Esopus shales		121–383

Blackish, arenaceous shales with Spirophyton caudagalli (Van.) Hall. The upper five or six feet of this formation is a very heavy sandstone, somewhat calcareous, which seems to gradually pass into the Schoharie grit. Only that however, which contains fossils has been referred to the Schoharie.

Oriskany sandstone		1–262

A brownish black, crystalline sandstone which weathers to a light brown porous sandstone. In the creek about a mile below the village this rock is almost black and at the same distance north

Feet Total

of it numbers of the weathered blocks may be found, while about one mile northeast of the village it forms the floor of a terrace from a quarter to a half mile in width.

Becraft limestone 20–261

A massive light gray limestone containing many fossils among which are large numbers of Aspidocrinus scutelliformis Hall. As this formation was not well exposed in the line of the regular section, the measurement was taken about half a mile north of it at Mr Gilbert Kniffens. The fossils are:

1 Aspidocrinus scutelliformis *H.* aa
2 Stropheodonta becki *H.* rr
3 Leptaena rhomboidalis (*Wilck.*) *H. & C.* rr
4 Spirifer concinnus *H.* rr
5 Strophonella punctulifera (*Con.*) *H. & C.* a
6 Atrypa reticularis (*Lin.*) *Dal.* c
7 Orthis (Rhipidomella) discus *H.* rr
8 O. (R.) oblata *H.* r
9 O. (Dalmanella) planoconvexa *H.* (?) rr
10 Orthothetes woolworthanus (*Hall*) *H. & C.*=Strophomena woolworthana *H.* rr

Feet Total

New Scotland beds 127–241

A gray, shaly fossiliferous limestone with occasional beds of massive limestone forming a gentle slope. On account of the shaly character of this formation a good exposure is seldom obtained. The fossils are:

1 Spirifer macropleura (*Con.*) *H.* aa
2 S. cyclopterus *H.* a
3 S. perlamellosus *H.* r
4 Leptaena rhomboidalis (*Wilck.*) *H. & C.* c
5 Leptaenisca concava (*Hall*) *H. & C.* c
6 Stropheodonta (Leptostrophia) becki *H.* a
7 S. varistriata *var.* arata *H.* rr
8 Eatonia medialis (*Van.*) *H.* r
9 E. singularis (*Van.*) *H.* rr
10 Strophonella punctulifera (*Con.*) *H. & C.* c
11 Orthis (Dalmanella) subcarinata *H.* rr
12 O. (D.) planoconvexa *H.* r
13 O. (D.) perelegans *H.* rr
14 O. (Rhipidomella) oblata *H.* rr
15 O. (Orthostrophia) strophomenoides *H.* rr
16 Meristella laevis (*Van.*) *Whitfield* r
17 M. bella *H.* (?) rr
18 M. arcuata (*Hall*) *H. & C.* rr
19 Atrypina imbricata (*Hall*) *H. & C.* rr
20 Uncinulus nucleolatus (*Hall*) *H. & C.*= Rhynchonella nucleolata *H.* rr
21 U. vellicatus (*Hall*) *H. & C.* rr
22 U. abruptus (*Hall*) *H. & C.* rr
23 U. pyramidatus (*Hall*) *H. & C.* rr

24 Stenochisma formosum (*Hall*) *H. & C.*= Rhynchonella formosa *H.* rr
25 S. altiplicatum (*Hall*) *H. & C.* rr
26 Orthothetes woolworthanus (*Hall*) *H. & C.*=Strophomena woolworthana *H.* r
27 Coelospira concava (*Hall*) *H. & C.* r
28 Orbiculoidea discus (*Hall*) *H. & C.* (?) rr
29 Trematospira *sp.* rr
30 Avicula communis *H.* r
31 Conocardium *sp.* rr
32 Dalmanites pleuroptyx (*Green*) *H.* c
33 Phacops logani *Hall* (?) rr
34 Platyceras *cf.* gebhardi *Con.* rr
35 P. ventricosum *Con.* rr
36 Streptelasma strictum *H.* a
37 Favosites sphericus *H.* rr
38 Chaetetes (Monotrypella) arbusculus *H.* rr
39 C. colliculatus *H.* rr
40 Tentaculites elongatus *H.* rr
41 Ptilodictya nebulosa *H.* rr
42 Fenestella *sp.* r
43 Lichenalia *sp.* rr

	Feet	Total
Coeymans limestone..............................	36–	114

A massive dark gray limestone which breaks into very irregular blocks. Fossils are not very plentiful and are very difficult to obtain unless the rock has been slightly burned. This formation is not as conspicuous here as it is farther north and the dividing line between it and the shaly [New Scotland] above is not well shown. The fossils are:

1 Sieberella galeata (*Dal.*) *H. & C.*= Pentamerus galeatus (*Dal.*) r
2 Strophonella punctulifera (*Con.*) *H. & C.* r
3 Stropheodonta (Brachyprion) varistriata (*Con.*) *H. & C.* r
4 Spirifer vanuxemi *H.* aa
5 S. perlamellosus *H.* rr
6 Atrypa reticularis (*Lin.*) *Dal.* r
7 Uncinulus mutabilis (*Hall*) *H. & C.*= Rhynchonella mutabilis *H.* r
8 Rhynchonella semiplicata (*Con.*) *H.* r
9 Meristella laevis *H.* rr
10 Orthis (Orthostrophia) strophomenoides *Hall* (?) rr
11 O. *sp.* rr
12 Anastrophia verneuili (*Hall*) *H. & C.* (?) rr
13 Favosites helderbergiae *H.* rr

Transitional beds..............................	12–	78

Limestone which in appearance and fracture is much like the Pentamerus [Coeymans] but which contains a mixture of Pentamerus and Tentaculite faunas, and is transitional between these two formations. Some of the fossils are:

1 Leperditia alta (*Con.*) *Hall* aa
2 Spirifer vanuxemi *H.* r
3 Pterinea communis *H.* rr

	Feet	Total
Manlius limestone		40–66

Dark blue thin bedded limestone which breaks into almost regular blocks. The fossils are:

1 Tentaculites gyracanthus (*Eaton*) *Hall* aa
2 Spirifer vanuxemi *Hall* a
3 Stropheodonta (Brachyprion) varistriata (*Con.*) *H.* r
4 Megambonia aviculoidea *H.* (?) c
5 Leperditia alta (*Con.*) *H.* c
6 Chaetetes (Monotrypella) arbusculus *H.* c

Covered by soil		26–26

25 Summary of the stratigraphy of Becraft mountain and vicinity near Hudson N. Y.[1]

In structure Becraft mountain is a synclinorium, the axes of which pitch southward except near the southern end where they rise again, through faulting, thus forming a basin structure. Along the eastern side the dip of the strata averages about 12 degrees into the mountain, but the western side shows a number of asymmetric anticlinal folds with steep, often overturned western limbs. The structure is furthermore complicated by a number of faults of which 21 have been definitely located. Several of these faults present interesting overthrust features while repetition of the strata is of common occurrence. The following formations occur:

	Feet	Total
Onondaga limestone.............................		20–25

This is found only in a synclinal trough forming the high ground in the southeastern part of the mountain. It is a dark gray, finely crystalline lime sandrock, rare in fossils. Those recorded are:

Chonophyllum
Favosites
Stromatopora
Zaphrentis *sp.*
Odontocephalus selenurus
Spirifer raricosta
Spirifer varicosus
Atrypa reticularis
Leptaena rhomboidalis
Orthothetes pandora
Euomphalus *sp.*

This is the highest formation of Becraft mountain.

[1] Grabau, A. W. Stratigraphy of Becraft Mountain, Columbia Co., N. Y. N. Y. State Paleontol. Rep't. 1903. p. 1030–79.

	Feet
Esopus and Schoharie grits	300

These are practically indistinguishable except by the fact that the Schoharie member (about 200 feet thick) shows good cleavage while the Esopus " checks " readily into small fragments. Good exposures of both formations are found along the Newman road which crosses Becraft mountain longitudinally. Both are dark silicious muds with scarcely any fossils and much affected by cleavage. The following fossils have been listed from the Schoharie:

Dalmanites anchiops
Phacops *cf.* bombifrons
Coelospira *cf.* camilla
Chonetes *cf.* arcuatus[1]

Oriskany quartzite	1–2

These are silicious limestones and quartzite beds which weather brown leaving the fossils as molds. Much chert is present. Few exposures in situ are met with, the best one being on the Newman road before it ascends the knoll of Esopus shales. In the meadows bordering the swamps around this knoll are loose fragments of this rock from which the characteristic fossils may be obtained. The commoner species are:

Cyrtolites expansus *Hall*
Diaphorostoma desmatum *Clarke*
D. ventricosum *Conrad*
Pterinopecten proteus *Clarke*
Rensselaeria ovoides *Eaton*
Megalanteris ovalis *Hall*
Coelospira dichotoma *Hall*
Leptocoelia flabellites *Conrad*
Spirifer arenosus *Conrad*
Sp. murchisoni *Castelnau*
Chonetes hudsonicus *Clarke*
Anoplia nucleata (*Hall*)
Orthothetes becraftensis *Clarke*
Leptostrophia oriskania *Clarke*
Brachyprion majus *Clarke*
Leptaena rhomboidalis (*Wilckens*)
Crania pulchella *Hall & Clarke*

The total number of species listed from this fauna by Clarke is 113. Of these 25 are Helderbergian, 24 occur in the normal Oriskany of Schoharie and the Helderbergs, 10 are found in the Onondaga and 1 in the Hamilton. The remainder are peculiar to it.

[1] Clarke, J. M. Oriskany Fauna of Becraft Mountain, Columbia Co. N. Y. N. Y. State Mus. Mem. 3.

	Feet
Port Ewen limestone............................	25

This is a dark lime sandrock resembling closely the Coeymans, and like it containing chert. The beds are transitional from the Becraft to the Oriskany both lithically and faunally. The best exposures are on the wood road which leads southward from the Jones quarries across the top of the hill. Among the common fossils are: Monotrypella tabulata (Hall) and Spirifer concinnus Hall (lower and middle beds), but such characteristic Oriskany species as Cladopora styphelia, Orthothetes becraftensis, Stropheodonta magnifica and Eatonia peculiaris also occur.

Becraft limestone	40–50

This is the type locality for this formation. It is abundantly exposed in the quarries on the mountain, being extensively used at present in the manufacture of Portland cement. The rock is a coarsely crystalline lime sandrock of light gray color passing locally into a shell rock or coquina. The most abundant fossils are:

Aspidocrinus scutelliformis *Hall* (in the lower bed)
Spirifer concinnus *Hall*
Sieberella pseudogaleata *Hall*
Uncinulus campbellanus (*Hall*)
Atrypa reticularis (*Linn.*)

New Scotland shale.........:.................	70–75

These are thin bedded calcareous and silicious clay mudrocks sometimes approaching to impure limestones. They represent a nearer shore deposit than the corresponding beds of Schoharie, though their thickness is less than in that region. Fossils, though abundant, are generally only preserved as molds. The following species are common:

Orthothetes woolworthanus *Hall*
Stropheodonta becki *Hall*
Strophonella headleyana *Hall*
Leptaena rhomboidalis (*Wilckens*)
Spirifer macropleura (*Conrad*)
S. perlamellosus *Hall*
Eatonia medialis *Vanuxem*
Dalmanites micrurus *Green*
D. nasutus *Conrad*

The best exposures are in the quarry at the crusher near Jonesburgh and above the cliff on the east-

ern part of the mountain. Numerous boulders are scattered or piled up in fences on the mountain and from these the fossils may be obtained.

	Feet
Coeymans limestone	42–45

This is a compact, finely crystalline, generally dark colored lime sandrock with many fossils, chief among which are Atrypa reticularis and Sieberella galeata. Layers of chert are not infrequent and in some outcrops form a constant and characteristic feature. The lower layers are rich in Favosites helderbergiae and are well exposed in the city quarry. The formation generally makes a cliff which is one of the characteristic features of the mountain. Above the cliff is a sloping bank formed by the thinner bedded upper Coeymans strata, which are transitional to the New Scotland. The common species here are:

Fistulipora torta *Hall*
Leptaena rhomboidalis (*Wilckens*)
Stropheodonta varistriata arata *Hall*
Spirifer perlamellosus *Hall*
Atrypa reticularis *Linne*
Sieberella galeata (*Conrad*)

With these are other species more characteristic of the higher beds.

Manlius limestone	55

This rests unconformably on the upturned Hudson river slates, the contact being exposed at the northern end of the mountain near the old Greenport tavern, at the place where the great spring of the Hudson aqueduct issues. The rock is throughout a banded lime mudrock and fossils are extremely rare, Leperditia alta alone occurring at intervals. Several Stromatopora beds occur in the upper part of the series, the highest of them forming the terminal member of the Manlius. In it occurs a modified Cobleskill fauna, the following species having been found:

Stromatopora (Syringostroma) *sp.* cc
Spirifer vanuxemi *Hall* c
S. corallinensis *Grabau* r
S. eriensis *Grabau* var. c
Camarotoechia hudsonica *Grabau* c
Rhynchospira excavata *Grabau* rr
Whitfieldella *cf.* nitida *Hall* rr
Gastropod
Leperditia alta c

The transition to the Coeymans is abrupt. These higher beds are best exposed in the city quarry near the Hudson cemetery.

Hudson river beds. The lowest beds exposed in this region are the Hudson river shales and sandstones. These are best shown at the northern end of Mt Moreno, just south of the city of Hudson. A quarry at the extreme northern end of the hill shows mudrocks and sandrocks, forming a pitching anticline. Some of the beds are carbonaceous and in these graptolites of lower Champlainic or Beekmantown age occur. The following species are common:

Phyllograptus angustifolius *Hall*
P. postremus *Rued.*
Trigonograptus ensiformis *Hall*
Climacograptus pungens *Rued.*
Diplograptus dentatus *Brogn.*

These beds represent according to Ruedemann, the third Deep kill zone of the lower Hudson river faunas.

Cambric strata have been reported from Mt Moreno but they have not been definitely located. Higher up on the northern face of the hill is a quarry in shales with a Normanskill or middle Trenton graptolite fauna comprising Coenograptus gracilis Hall, Didymograptus sagittarius Hall, D. tenuis Hall, and other species.

Burden conglomerate. A calcareous conglomerate in which the pebbles are chiefly limestones cemented by a more or less calcareous cement is exposed east of Mt Becraft on a small tributary of Claverack creek. Fragments of it are found scattered over Mt Becraft, and it also occurs at the Burden iron mine five miles south of Hudson. Its age is probably lower Champlainic.

26 General section of the strata of the southern Helderbergs and the cement region of Ulster county, N. Y.[1]

		Feet
Catskill		1725
White conglomeratic sandstone, forming the summit of Slide mountain. It is a coarse grained heavy-bedded moderately hard sandstone containing disseminated pebbles of quartz or light colored quartzite, and streaks of conglomerate. Greatest thickness on Slide mountain	350	

[1]Darton, N. H. Geology of Ulster County N. Y. N. Y. State Geol. 13th An. Rep't. 1894. v.1, p.297 *et seq.*
Prosser, Charles S. Classification and Distribution of the Hamilton and Chemung Series of Central and Eastern N. Y., pt 2. N. Y. State Geol. 17th An. Rep't and N. Y. State Mus. 51st An. Rep't. 1899. v.2.
Van Ingen, G. and Clark, P. E. Disturbed Fossiliferous Rocks in the Vicinity of Rondout N. Y. N. Y. State Paleontol. Rep't 1902. 1903. p.1177 *et seq.*

		Feet
Red conglomeratic sandstone. Coarse heavy bedded sandstone of dull brownish hue, containing disseminated pebbles and conglomeratic streaks, differing from the overlying beds chiefly in color. In both series the pebbles and conglomeratic streaks are scattered and irregular, while the sands are often coarsely cross-bedded. Thin layers of red shale occur, and locally gray sandstones. The rocks have much more the aspect of a continental formation than of an estuarine formation, and may very well represent the accumulations on the flood plains and deltas of large rivers, at a moderate level above the sea. Thickness of conglomeratic sandstone	1375	
Oneonta (*Upper flagstone series*)		3000
Thin and thick bedded sandstones from 20 to 200 feet thick with intercalated red shales up to 30 feet thick. The sandstones are chiefly light gray to gray brown in color, and contain many beds suitable for flagstones or "blue stone." Heavy cross-bedded layers occur, and occasional dark shale layers. Local occurrences of conglomerates. The formation is best exposed in the upper Esopus and Rondout valleys.		
Sherburne (*Lower flagstone series*)		500
Thin bedded sandstones, with intercalated beds of dark shale. The sandstones are in masses from a few inches to 40 feet in thickness, greenish gray to light bluish gray or dark gray in color and are extensively quarried as flagstones. Occasional thin streaks of quartz conglomerate occur.		
Hamilton shales		600
Dark gray to black or brown shales with thin arenaceous beds in the upper part. The best exposure is in Mount Marion, southwest of Saugerties.[1] The following species are recorded by Prosser from this locality.[2]		

[1] Mt Marion station is on the West Shore Railroad about 8 miles north of Kingston. The best locality for collecting fossils is in a cliff 100 feet high on the west bank of the Plaaterskill, where this stream is crossed by the highway west of Mt Marion station.

[2] Prosser, Charles S. Classification and Distribution of the Hamilton and Chemung Series of Eastern N. Y., pt 2. N. Y. State Mus. 51st An. Rep't 1899. v. 2.

1 Bellerophon *sp.* rr
2 Nyassa arguta *Hall* rr
3 N. recta *Hall* rr
4 Orthonota parvula *Hall* r
5 Paracyclas lirata (*Con.*) *Hall* r
6 Spirifer granulosus *Hall* a
7 S. mucronatus (*Con.*) *Bill.* r
8 Orthis (Schizophoria) impressa *Hall* r
9 Chonetes scitulus *Hall* r
10 C. *cf.* setigerus *Hall* r
11 C. coronatus (*Con.*) *Hall* rr
12 Pleurotomaria rotalia *Hall* (?) rr
13 Orthoceras *sp.* rr
14 Palaeoneilo plana *Hall* rr
15 Nuculites oblongatus (*Con.*) *Hall* rr
16 N. triqueter *Con.* rr
17 Nucula corbuliformis *Hall* r
18 N. bellistriata (*Con.*) *Hall* r
19 Plant stems rr
20 Modiomorpha concentrica (*Con.*) *Hall* r
21 Grammysia *sp.* rr
22 Dignomia alveolata (*Hall*) *H. and C.* rr
23 Lingula densa *Hall* r

Feet

Onondaga limestone 75

Light bluish gray dense-textured and massively bedded limestone with much chert in thin beds and elongated lenses, most frequently in the upper bed. The basal beds are often silicious or argillaceous lime sandrocks forming passage beds from those below. The commoner fossils occur in it, specially Atrypa reticularis, Leptostrophia perplana, Platyceras dumosum, Leptaena rhomboidalis, etc.

Schoharie and Esopus 300

Argillaceous quartz sandrock to silicious clay mudrock, dark colored often black when fresh and commonly much cleaved, seldom shaly. On weathered surfaces it breaks up into small irregular checkers. Spirophyton cauda-galli occurs on some surfaces. In the upper layers occur Leptocoelia acutiplicata, Atrypa spinosa, and an Orbiculoidea?. These layers become more calcareous and merge into the overlying Onondaga.

Oriskany .... 5 -60

Quartz conglomerates, and sandstones or quartzites, calcareous quartz sandrock and silicious lime sandrock. Fossils are abundant and in the decomposed portions weather in relief making specimens of great beauty. Van Ingen and Clark list 94

species from Glen Erie, 26 of which are also New Scotland species. The abundant and common species are:

Monotrypella sphaerica *Hall* a
Edriocrinus sacculus *Hall* c
Pholidops terminalis *Hall* a
P. ovata *Hall* c
Rhipidomella oblata *Hall* c
R. musculosa *Hall* a
Dalmanella perelegans *Hall* c
D. planoconvexa *Hall* a
D. ventricosa *Hall* a
Brachyprion schuchertanum *Clarke* c
B. majus *Clarke* c
Leptostrophia becki *Hall* c
L. magnifica *Hall* a
L. magniventer *Hall* a
L. oriskania *Clarke* c
Orthothetes becraftensis *Clarke* a
O. woolworthanus *Hall* c
Hipparionyx proximus *Vanuxem* c
Chonostrophia complanata *Hall* c
Chonetes hudsonicus *Clarke* c
Anoplia nucleata *Hall* a
Plethorhyncha pleiopleura *Hall* c
P. fitchana *Hall* c
Camarotoechia oblata *Hall* a
Eatonia peculiaris *Conrad* a
Coelospira dichotoma *Hall* a
C. concava *Hall* c
Leptocoelia flabellites *Conrad* a
L. acutiplicata *Conrad* c
Cyrtina rostrata *Hall* a
Spirifer arenosus *Conrad* c
S. murchisoni *Castelnau* a
S. tribulis *Hall* a
S. cyclopterus *Hall* a
S. saffordi *Hall* a
S. modestus *Hall* c
Metaplasia pyxidata *Hall* c
Ambocoelia *sp. nov.* c
Meristella lentiformis *Clarke* c
M. lata *Hall* c
Nucleospira ventricosa *Hall* c
Parazyga deweyi *Hall* c
Oriskania navicella *Hall and Clarke* c
Megalanteris ovalis *Hall* c
Beachia suessana *Hall* c
Rensselaeria ovoides *Eaton* c
Actinopteria arenaria *Hall* c
Tentaculites elongatus *Hall* c
Diaphorostoma desmatum *Clarke* c
D. ventricosum *Conrad* a
Platyceras gebhardi *Hall* c
P. nodosum *Conrad* a
P. reflexum *Hall* c
Dalmanites pleuroptyx *Green* c
D. stemmatus *Clarke* c
Spirophyton caudagalli *Vanuxem* c

	Feet
Port Ewen	30–150

Silicio argillaceous lime sandrocks and lime mudrocks, often pyritiferous. A well marked concretionary (or conglomeratic ?) structure is seen in the typical locality on the cut of the West Shore railroad near the Wilbur bridge. These nodules of lime mark the bedding plane and they readily weather away leaving large cavities. In these hollows silicified fossils are often found. Among the commoner species are:

Leptaena rhomboidalis (*Wilck.*) c
Atrypa reticularis *Linne* a
Strophonella leavenworthana *Hall* c
Dalmanella perelegans *Hall* c
Orthothetes woolworthanus (*Hall*) c
Spirifer perlamellosus *Hall* c
Rhipidomella oblata *Hall* c
Meristella laevis (*Vanuxem*) c
Uncinulus campbellanus (*Hall*) c
Phacops logani *Hall* c
Chaetetes *sp.* ? c
Hindia fibrosa (*Roemer*) c
Tentaculites elongatus *Hall* c
Anastrophia *cf.* verneuili (*Hall*)
Spirifer concinnus *Hall* c
Acidaspis tuberculatus *Hall* c

The maximum thickness is at Port Ewen.

Becraft limestone	40

Massive bedded light colored lime sandrock, often becoming a shell limestone of great purity and consisting of brachiopod shells and crinoids. The lower beds are more argillaceous, being a transition from the New Scotland below. The middle 18 or 20 feet range from 94 to 97% calcium carbonate. The last recorded outcrops of this rock are below High Falls. From the Rondout region van Ingen and Clark record the following species:

Upper portion

Sieberella pseudogaleata *Hall* a
Atrypa reticularis *Linne* a
Spirifer concinnus *Hall* a
Rhipidomella oblata *Hall* c
Crinoid fragments a
Stropheodonta arata *Hall* r
Leptaena rhomboidalis (*Wilck.*) c
Nucleospira ventricosa *Hall* c
Spirifer perlamellosus *Hall* c
Oriskania (?) *sp.* ? r

Middle portion

Aspidocrinus scutelliformis *Hall* aa
Spirifer concinnus *Hall* aa

Atrypa reticularis *Linne* c
Lichenalia *sp.* ? c
Meristella *sp.* ? c
Rhipidomella oblata *Hall* c
Sieberella pseudogaleata *Hall* a
Rensselaeria aequiradiata (*Conrad*) c
Uncinulus nobilis *Hall* c
U. campbellanus (*Hall*) aa
Stropheodonta becki *Hall* a
Stenoschisma formosum *Hall* r
Camarotoechia transversa *Hall* c
Schizophoria multistriata *Hall* c
Phacops logani *Hall* r
Stropheodonta *cf.* varistriata (*Conrad*) c

	Feet
New Scotland shaly limestone......................	60–100 ?

Dark gray shaly limestone, mudrocks and sandstones alternating and occasionally silicious sandstones occurring. Much chert occurs in the lower portion, while the upper contains more limestone bands; grading up into the Becraft. The fossils recorded by van Ingen and Clark from the exposures about Rondout are:

Upper New Scotland

Spirifer cyclopterus *Hall* aa
Rhipidomella oblata *Hall* c
Proetus *sp.* ? rr
Stropheodonta *sp.* ? r
Camarotoechia transversa *Hall* aa
Spirifer concinnus *Hall* c
Ostracods, several species c
Dalmanites pleuroptyx (*Green*) r
Rensselaeria mutabilis *Hall* r
Actinopteria textilis *Hall* r
Sieberella pseudogaleata *Hall* r
Stropheodonta becki *Hall* c
Aspidocrinus scutelliformis *Hall* aa
Atrypa reticularis *Linne* c
Orthothetes woolworthanus *Hall* c
Stenoschisma formosum *Hall* a
Meristella *sp.* ? r
Uncinulus campbellanus *Hall* c
Spirifer perlamellosus *Hall* r

Middle New Scotland

Leptaena rhomboidalis (*Wilck.*) a
Orthothetes woolworthanus (*Hall*) aa
Strophonella radiata (*Vanuxem*) aa
Dalmanella perelegans *Hall* c
Anoplotheca concava (*Hall*) c
Acidaspis tuberculatus (*Conrad*) c
Spirifer perlamellosus *Hall* c
Dalmanites pleuroptyx (*Green*) r
Uncinulus vellicatus *Hall* r
Cyrtoceras, small species rr
Meristella *sp. indet.* r
Phacops logani *Hall* r
Eatonia medialis *Hall* c
Pholidops *sp.* ? r

Actinopteria textilis (*Hall*) r
Chonetes *sp.* ? r
Lichenalia torta *Hall* c
Chaetetes sphaericus *Hall* (branching form) c
Platyostoma, 2 species r
Strophonella punctulifera (*Conrad*) r
Stropheodonta arata *Hall* c
S. beckí *Hall* c
Camarotoechia bialveata *Hall* r
C. inutilis *Hall* r
Strophonella cavumbona *Hall* c
Anoplia nucleata *Hall* r
Isochilina, small c

Lower New Scotland

Orthothetes woolworthanus *Hall* aa
Strophonella punctulifera (*Conrad*) c
Rhipidomella oblata *Hall* c
Crinoid stems aa
Isochilina, minute species aa
Monotrypella sphaerica *Hall* c
Stropheodonta becki *Hall* aa
Leptaena rhomboidalis (*Wilck.*) aa
Phacops logani *Hall* c
Dalmanites pleuroptyx (*Green*) c
Spirifer cyclopterus *Hall* c
S. macropleura (*Conrad*) c
Proëtus protuberans *Hall* r
Eatonia medialis (*Vanuxem*) c
Acidaspis tuberculatus (*Conrad*) r
Actinopteria textilis (*Hall*) c
Platyostoma *sp.* ? r
Eatonia peculiaris (*Conrad*) c
Meristella laevis (*Vanuxem*) c
Dalmanella perelegans *Hall* c
Spirifer perlamellosus *Hall* c
Hindia fibrosa (*Roemer*) c
Strophonella *sp.* ?
Lichenalia torta *Hall* c
Atrypina imbricata *Hall* c

	Feet
Coeymans limestone	30–60

Dark lime mudrocks, sometimes argillaceous and with much flint in the middle portion. In the Delaware avenue quarry at Rondout, the following subdivisions are made by van Ingen and Clark:

		Feet	Inches
Coeymans 50 feet, 5 inches	25 Shaly limestone.	4	..
	24 Shaly limestone..............	11	6
	23 Cherty limestone............	12	1
	22 Cherty limestone	11	..
	21 Hard limestone..............	7	..
	20 Basal, marly, transition	4	10

From the highest bed (25) they obtained the following species:

Sieberella galeata *Dalman* aa
Atrypa reticularis *Linne* a
Uncinulus nucleolatus *Hall* c
Atrypina imbricata *Hall* c

Spirifer perlamellosus *Hall*
Bilobites varica (*Conrad*) c
Dalmanella perelegans *Hall* c
Nucleospira ventricosa *Hall* r
Parazyga deweyi *Hall* r
Lichenalia torta *Hall* r
Platyceras *sp.* ? r

From bed 24 they obtained:

Sieberella galeata *Dalman* aa
Leptaena rhomboidalis (*Wilck.*) c
Atrypa reticularis *Linne* a
Stropheodonta varistriata (*Conrad*) c
Hindia fibrosa (*Roemer*) c
Leptaenisca concava *Hall* (?) r
Rhynchospira globosa *Hall* r
Spirifer cyclopterus *Hall* r
Orthothetes *sp.* ?
Dalmanella perelegans *Hall* c
Uncinulus nucleolatus *Hall*
Lichenalia torta *Hall*
Spirifer octocostatus *Hall* (?)
Monotrypella sphaerica *Hall*
Strophonella punctulifera (*Conrad*)
Rhipidomella, small species.

From bed 23 they obtained:

Atrypa reticularis *Linne* a
Hindia fibrosa (*Roemer*) a
Sieberella galeata *Dalman*, a pauciplicate form
S. galeata, large form with coarse bifurcating plications
Anastrophia verneuili *Hall* r
Dalmanella perelegans *Hall* c
Strophonella punctulifera (*Conrad*) r

From bed 22:

Atrypa reticularis *Linne* a
Sieberella galeata *Dalman* c
Hindia fibrosa (*Roemer*) a
Favosites helderbergiae *Hall* c
Uncinulus nucleolatus *Hall* c
Sponge, n. gen. et. sp. ?

From bed 21:

Lichenalia torta *Hall* c
Dalmanites micrurus (*Green*) c
Sieberella galeata *Dalman* c
Actinopteria textilis (*Hall*) c
Lamellibranch, large, *gen. et sp. nov.* ?

From bed 20:

Lichenalia torta *Hall* aa
Spirifer cyclopterus *Hall* c
S. concinnus *Hall* c
S. perlamellosus *Hall* r
Rhipidomella oblata *Hall* c
R. oblata emarginata *Hall*
Uncinulus mutabilis *Hall* c
Strophonella punctulifera (*Conrad*) c
S. varistriata (*Conrad*) c
Sieberella galeata (*Dalman*) c
Monotrypella sphaerica *Hall* c
Meristella laevis (*Vanuxem*) r
Stenoschisma formosum (*Hall*) r

Rhynchospira globosa *Hall* r
Rhynchospira *sp. nov.* c
Orthothetes woolworthanus *Hall* r
Spirifer macropleura (*Conrad*) r
Megambonia *sp.* ? c
Strophonella leavenworthana r
Leptaena rhomboidalis (*Wilck.*) c
Atrypa reticularis *Linne* r
Small individuals with regular fine radial ribs.
Actinopteria textilis (*Hall*) r
Stropheodonta becki *Hall* r
S. *cf.* planulata *Hall* r
Dalmanella subcarinata *Hall* r
Favosites helderbergiae *Hall*
Common in the very lowermost portion.
Pholidops *sp.* ? r
Camarotoechia semiplicata *Conrad* c
Bronteus barrandii *Hall* r
Proetus protuberans *Hall* c
Dalmanites pleuroptyx (*Green*) c
D. micrurus (*Green*) r
Phacops logani *Hall* c
Nucleospira *sp.* ? r
Cyrtina dalmani *Hall* r
Orthoceras *sp.* ? r
Annulated type.
Bryozoa and some ostracods, unidentified

	Feet
Manlius beds	20–42

Lime mudrocks and lime sandrocks generally quite pure and fossiliferous at intervals. Some beds are argillaceous and very dark colored. They are mostly thin bedded. Van Ingen and Clark make the following subdivision in the Spring street quarry at Rondout:

		Feet	Inches
Manlius limestones 42 feet	19 Hard dove, massive	6	4
	18 Light gray, compact	6	8
	17 Stromatopora, upper bed	7	6
	16 Stromatopora, bottom	5	5
	15 Dark blue with gray seams....	5	8
	14 Dark blue.....................	3	10
	13 Thin banded	2	5
	12 Gray band	4	6

The lower beds (12–16) contain the common species: Leperditia alta, Spirifer vanuxemi and Stropheodonta varistriata. Bed 16 contains some Stromatopora and the following fauna:

Loxonema fitchi *Hall* c
Holopea pervetusta (*Conrad*) c
H. subconica *Hall* c
Loxonema *sp.* ?
Murchisonia minuta *Hall*
Hormotoma, small species
Modiolopsis dubia *Hall*

Holopea elongata *Hall*
Laevidentalium *sp.* ?
Spirifer vanuxemi *Hall* r
Leperditia alta *Conrad* c
Holopea antiqua (*Vanuxem*)
Zaphrentis *sp.* ?

Bed 17 is a veritable Stromatopora reef. Bed 18 contains in the lower part the following fauna:

Spirifer vanuxemi *Hall* c
Tentaculites gyracanthus (*Eaton*) c
Stropheodonta varistriata *Conrad* c
Leperditia alta *Conrad* c
Ostracods, numerous specimens of two or three species
Hormotoma, small species
Holopea elongata *Hall*

Both faunas, above and below the Stromatopora bed are specially characterized by the occurrence of gastropods.

	Feet
Rondout	20–31

Chiefly lime mudrocks, mostly unfossiliferous, and containing beds of workable cement. At Rondout the following subdivision has been made by van Ingen and Clark:

			Feet	Inches
Upper with gray cement beds 19 feet, 6 inches	11	Paving block or mud crack......	3	3
	10	Prismatic or five point	4	4
	9	Leperditia bed	2	1
	8	Curly, variable....................	..	8–19
	7	Soft gray cement.................	3	3
	6	Hard gray cement...............	5	
	5a	Middle ledge	..	7
Lower or dark cement beds 9 feet, 7 inches to 11 feet, 2 inches	5	Hard black cement..............	4	8
	4	Soft black cement...............	4	5
	3	Footledge.................. 6″ to	2	

Hartnagel and van Ingen and Clark have suggested that the upper beds (6–11) alone represented the Rondout and that the lower beds 3–5, represented the Rosendale cement beds, the seven inch middle ledge (5a) representing the Cobleskill. I believe however that the whole series here represents the Rondout and that the underlying 5–7 feet of "Coralline limestone" which rests directly on the upturned Hudson river sandstones in this region, is the Cobleskill, while the Rosendale cement bed and the Wilbur limestone are absent altogether. Both of these appear at the Wilbur bridge section and south of Wilbur, where the Cobleskill is 10–15 feet thick, which thickness it retains as far as Rosendale or beyond. The Rondout cement above it is 19 feet thick at the Wilbur bridge exclusive of the mud crack layer or five point bed. At Eddyville the same bed is 7 feet thick exclusive of the five point, the Cobleskill being 10 feet.

Beds 11 and 10 of the Rondout section show mud crack structure of different sizes. These features have been seen in other regions as well, though the beds showing them do not necessarily belong to the same zone everywhere. Occasionally ripple marks are shown as in the Wilbur Bridge section. Bed 9 is filled with Leperditia alta, containing also Beyrichia sp. ?, Modiolopsis dubia and Spirifer vanuxemi. This is a Manlius fauna and reference of these beds to the Rondout appears to be wholly on lithic grounds. Since the two formations are so closely related, it does not matter much where the line between them is drawn. The middle ledge (5a) contains Orthothetes interstriatus and Camarotoechia? lamellata, two typical Cobleskill species, but also found in the Rondout in the Schoharie region [*see* Section 2].

	Feet
Cobleskill	14–18

Dark, often impure, fossiliferous lime sandrock, with an abundance of Halysites. At Binnewater it is 14 feet thick, while at the section near Wilbur bridge it is nearer 18 feet. In both of these localities it is underlain by the Rosendale cement bed, but at Rondout this latter is absent, if my interpretations are correct, and the upper 5 to 7 feet of the Cobleskill rest directly on the Normanskill sandstones. Northward the Cobleskill disappears and is overlapped by the Rondout as shown by Hartnagel. The relationship of the strata at Rosendale and Rondout are shown in the following diagram [fig. 204].

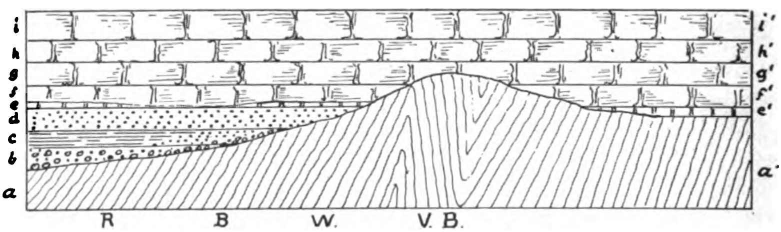


Fig. 204 Diagram showing relationship of Champlainic and Siluric strata in Ulster county. R=Rosendale. B=Binnewater. W=Wilbur bridge. V.B.=Vlightberg. Kingston. *a-a'*, Normanskill shale, *b*, Shawangunk conglomerate, *c*, High Falls shale, *d*, Binnewater sandstone, *e-e'*, Wilbur limestone, *f-f'*, Rosendale waterlime, *g-g'*, Cobleskill, *h-h'*, Rondout waterlime, *i-i'*, Manlius

Rosendale cement	10–21

Fine bedded gray lime mudrocks with the proper admixture of silica to make it a natural cement rock. At Rosendale 22 feet are quarried, while near Wil-

	Feet
bur there are not much over 10 feet. At one point near Binnewater the thickness decreases to 4 feet, though its maximum here is 15 feet [*see ante,* fig. 33]. In age this formation is approximately equivalent to the Brayman shales of Schoharie, and the Bertie of Western New York.	
Wilbur limestone	0–8?
Fossiliferous lime sandrock like the Cobleskill. *Halysites catenulatus, Leptaena rhomboidalis* and *Atrypa reticularis* characterize it. On Rondout creek the Wilbur rests directly on the Binnewater quartzites, but at Whiteport and Binnewater itself this limestone is wanting. It thus appears to be only a local phase of the base of the Rosendale cement, the argillaceous lime mudrocks being deposited in portions of the region, while in others Siluric organisms were able to gain a foothold and flourish for a time, adding their debris as lime sandrock to form the Wilbur limestone. At the Wilbur bridge section, a foot or two of the Wilbur limestone underlies the Rosendale cement bed, and grades downward into the Binnewater.	
Binnewater sandstone	0–22
Light gray to buff and brown quartz sandrocks often becoming quartzitic and generally in thin layers. Minute cross-bedding is found in many of the beds. At Binnewater and northward to Rondout the Binnewater sandstones rest directly on the Hudson river shales and sandstones while southward the Shawangunk conglomerate and the red shales intervene between them.	
High Falls shale..................................	0–25
In the vicinity of Rosendale and westward red shales lie just below the Binnewater sandstone and above the conglomerate. At Rosendale Darton records 25 feet of the red shales and 22 feet of the quartzites above the conglomerate. These shales were called by Darton and others the Medina shales, but Hartnagel has shown them to be of Salina age, and used the term High Falls shale, from their exposure at that locality.[1]	

[1] N. Y. State Paleontol. An. Rep't. 1903.

	Feet
Shawangunk grit	0–210

Silicified quartz conglomerate, making its first appearance in the Binnewater region and becoming most prominent southward, where it forms the summit of the Shawangunk range. The pebbles are mostly well worn, generally small or of moderate size, the matrix being a quartz sand and silicious cement. Locally it passes into a quartz sandstone or quartzite. Darton records 45 feet near Rosendale and 100 feet in the ridges to the south. At Lake Mohonk he finds 160 feet; at Peterkill falls 210 feet, while near Ellenville it is about 200 feet, which is its average thickness in the Shawangunk range [fig. 205].

Fig. 205

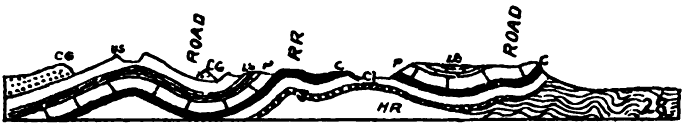


Fig. 206 Section at the north end of the fifth Binnewater, Ulster co. (After Darton) HR=Hudson river shales, S=Shawangunk, Cl=High Falls shale and Binnewater sandstone, C=cement beds (Rosendale and Rondout, with Cobleskill between), P=Manlius and Coeymans, LS=New Scotland beds, US=Becraft and Port Ewen, CG=Oriskany and Esopus

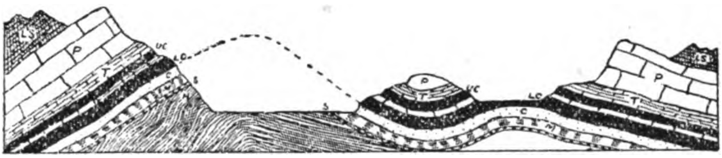


Fig. 207 Section of the cement district 1 mile south of Whiteport station, Ulster co. (After Darton) H=Hudson river shales, S=Shawangunk, M=High Falls shale, C=Binnewater sandstone, LC=Rosendale cement,—Cobleskill, UC=Rondout cement, T=Manlius, P=Coeymans, LS=New Scotland

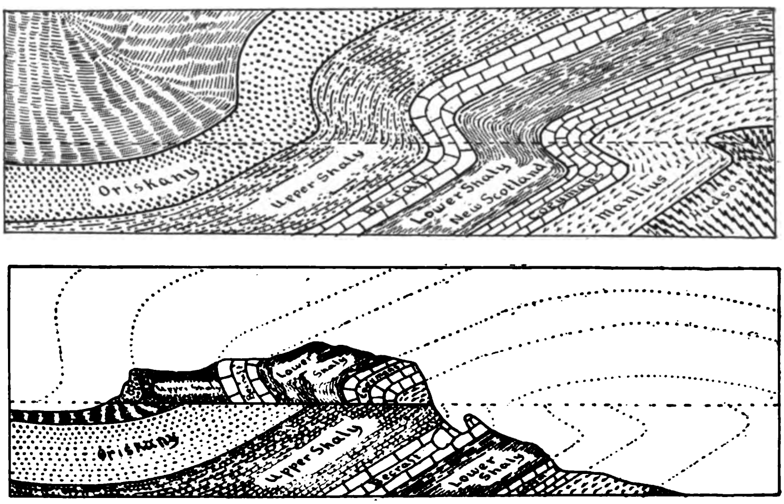


Fig. 208 Section of North hill, Kingston, showing strata as originally folded, position of thrust plane (upper) and present character after thrust and erosion (lower).

Unconformity (covering the interval from about Middle Champlainic to Upper Siluric (Salina).

Hudson river strata ranging in age from Normanskill (Middle Trenton) or earlier to Lorraine, and of unknown thickness.

In structure the cement region is a series of symmetric anticlines and synclines of the Appalachian type [fig. 206–7]. This has been described by Lindsley[1], Dale[2], Davis[3], Darton[4], and for the northern region by van Ingen and Clark[5]. In the Kingston region the structure is further complicated by faults which have been worked out with much care by van Ingen and Clark. One of the most important of the faults is the great overthrust on North hill, Kingston, by which many of the strata are repeated, the Rondout waterlime resting on the lower Port Ewen beds [fig. 208].

[1] Poughkeepsie Proc. Soc. Nat. Sci. 2:44–48.
[2] Am. Jour. Sci. ser. 3. 16:293–95.
[3] Mus. Comp. Zool. Bul. 7:311–29; and Am. Jour. Sci. ser. 3. 26:389–95.
[4] N. Y. State Geol. 13th An. Rep't. 1:291–372.
[5] N. Y. State Paleontol. An. Rep't 1902; N. Y. State Mus. Bul. 69. p. 1176–1227. 1903.

Chapter 7

LISTS OF FOSSILS FOUND IN THE FORMATIONS OF THE SCHOHARIE REGION

These lists have been compiled from all available sources. The volumes of the *Palaeontology of New York* have furnished a large portion of them and the lists published by Prosser in his numerous sections of this region have been used freely. Hartnagel's list of Cobleskill fossils has been reproduced with a few alterations and finally, collections made during the study of the region have been used as a basis for these lists. They are by no means complete, but incomplete as they are they will serve a useful purpose to the student of this region.

A Fossils of the Cobleskill limestone of the Schoharie region

After Hartnagel

Corals

1 Acervularia ? inequalis *Hall*
2 Diplophyllum coralliferum *Hall*
3 Enterolasma caliculus *Hall*
4 Cyathophyllum hydraulicum *Simpson*
5 Favosites helderbergiae *var.* precedens *Schuchert*
6 Halysites catenulatus *Linné*
7 Stromatopora cf. antiqua *Nicholson & Murray*
8 S. constellata *Hall*

Bryozoa

9 Chaetetes *sp.*
10 Fenestella *sp.*
11 Hederella *sp.*
12 Lichenalia *cf.* concentrica *Hall*
13 Trematopora *sp.*

Crinoids

14 Thysanocrinus *sp.*

Brachiopods

15 Atrypa reticularis *Linnaeus*
16 Camarotoechia litchfieldensis *Schuchert*
17 Chonetes jerseyensis *Weller*
18 Leptaena rhomboidalis *Wilckens*
19 Orthothetes interstriatus *Hall*
20 Camarotoechia ? lamellata *Hall*
21 C. pisum *Hall & Whitfield*
22 Spirifer corallinensis *Grabau*
23 S. eriensis *Grabau*
24 Stropheodonta bipartita *Hall*
25 S. textilis *Hall*
26 Whitfieldella nucleolata *Hall*

Pelecypoda

27 Ilionia *cf.* canadensis *Billings*
28 I. galtensis *Whiteaves*
29 I. sinuata *Hall*
30 Mytilarca *sp.*
31 Pterinea securiformis *Hall*
32 P. subplana *Hall*
33 P. subrecta *Hall*
34 Tellinomya equilatera *Hall*

Gastropoda

35 Bellerophon auriculatus *Hall*
36 Bucania *sp.*
37 Murchisonia ? terebralis *Hall*
38 Pleurotomaria ? subdepressa *Hall*
39 P. *sp.*
40 Poleumita *cf.* crenulata *Clarke & Ruedemann*

Vermes

41 Spirorbis *sp.*

Cephalopoda

42 Trochoceras gebhardi *Hall*
43 T. turbinatum *Hall*
44 Cyrtoceras *sp.*
45 Gyroceras *sp.*
46 Kionoceras darwini *Billings*
47 Oncoceras trusitum *Clarke & Ruedemann*
48 Orthoceras expansum *Hall*
49 O. (large sp.)
50 Phragmoceras corallophilum *Clarke*

Pteropoda

51 Cornulites arcuatus *Conrad*
52 Tentaculites *sp.*

Ostracoda

53 Beyrichia (2 species)

Trilobita

54 Calymmene camerata *Conrad*
55 C. niagarensis *Hall*
56 Dalmanites *sp.*
57 Homalonotus *sp.*
58 Leperditia jonesi *Hall*
59 L. scalaris *Jones*
60 Lichas (Dicranogmus) ptyonurus *Hall*
61 Proetus *sp.*

B Fossils of the Rondout beds of the Schoharie region

1 Halysites catenularia *var.*[1]
2 Favosites helderbergiae precedens *Schuchert*
3 Stromatopora cf. antiqua *Nicholson & Murray*
4 Camarotoechia litchfieldensis *Schuchert*
5 Stropheodonta bipartita *Hall*
6 Orthothetes interstriatus *Hall*
7 Rhynchonella lamellata *Hall*
8 Spirifer corallinensis *Grabau*
9 S. eriensis *Grabau*[1]

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[1]Reported by Schuchert from the "cement rock at Schoharie". Am. Geol. 31:164.

10 Whitfieldella nucleolata *Hall*
11 Pterinea securiformis *Hall*
12 Orthoceras *sp.*
13 Beyrichia *sp.*
14 Leperditia *cf.* jonesi *Hall*
15 Gastropod *sp.*

C Fossils of the Manlius limestone of the Schoharie region

Crinoidea
1 Homocrinus scoparius *Hall*
2 Camarocrinus stellatus *Hall*

Vermes
3 Spirorbis laxus *Hall*

Bryozoa
4 Chaetetes (Monotrypella) arbusculus *Hall*
5 Monotrypa ? spinulosa *Hall & Simpson*

Brachiopoda
6 Stropheodonta varistriata (*Conrad*)
7 Spirifer vanuxemi *Hall*

Pelecypoda
8 Megambonia aviculoidea *Hall*
9 ? M. ovoidea *Hall*[1]
10 Modiolopsis ? dubia *Hall*
11 Avicula obscura *Hall*
12 Tellinomya nucleiformis *Hall*

Gastropoda
13 Holopea ? elongata *Hall*
14 Murchisonia extenuata *Hall*[1]
15 Loxonema fitchi *Hall*

Pteropoda
16 Tentaculites gyracanthus (*Eaton*)
17 T. irregularis *Hall*

Ostracoda
18 Beyrichia notata *Hall*
19 Leperditia alta (*Conrad*)

D Fossils of the Manlius–Coeymans transition beds of the Schoharie region

Crinoid segments

Bryozoa
1 Chaetetes (Monotrypella) arbusculus *Hall*
2 Fenestella *sp.*

Brachiopoda
3 Stropheodonta varistriata (*Con.*)
4 Strophonella punctulifera (*Con.*)
5 Spirifer vanuxemi *Hall*
6 Meristella laevis (*Van.*)
7 Camarotoechia ventricosa *Hall* ?
8 C. semiplicata (*Con.*) *var.*
9 Uncinulus mutabilis *Hall*

Pelecypoda
10 Megambonia aviculoidea *Hall*
11 Pterinea textilis (*Con.*)

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[1] Schoharie county; exact locality not known.

Pteropoda

12 Tentaculites gyracanthus (*Eaton*)

Vermes

13 Spirorbis laxus *Hall*

Ostracoda

14 Leperditia alta (*Con.*)
15 Beyrichia trisulcata *Hall*
16 B. notata *Hall*

E Fossils of the Coeymans limestone of the Schoharie region

Corals

1 Favosites helderbergiae *Hall*
2 Alveolites explanatus *Hall*

Crinoidea

3 Homocrinus scoparius *Hall*
4 Melocrinus pachydactylus (*Conrad*)
5 Lepadocrinus gebhardi (*Conrad*)

Bryozoa

6 Monotrypella abrupta (*Hall*)

Brachiopoda

7 Lingula perlata *Hall*
8 Stropheodonta varistriata (*Conrad*)
9 S. planulata *Hall*
10 Strophonella punctulifera (*Conrad*)
11 S. (?) conradi *Hall*
12 Leptaena rhomboidalis (*Wilckens*)
13 Delthyris perlamellosa (*Hall*)
14 Camarotoechia semiplicata (*Conrad*)
15 Uncinulus mutabilis *Hall*
16 Atrypa reticularis (*Linnaeus*)
17 Sieberella galeata (*Dalman*)

Pelecypoda

18 ? Cypricardinia concentrica *Hall*[1]
19 Megambonia aviculoidea *Hall*
20 Avicula (?) naviformis *Conrad*
21 A. umbonata *Hall*[1]
22 A. manticula *Conrad*[1]
23 A. obliquata *Hall*[1]

Gastropoda

24 Loxonema ? obtusum *Hall*
25 L. ? compactum *Hall*[1]
26 L. planogyratum *Hall*[1]

Cephalopoda

27 Orthoceras longicameratum *Hall*[1]
28 O. subtextile *Hall*
29 O. clavatum *Hall*
30 O. ?
31 O. helderbergiae *Hall*
33 O. rude *Hall*
34 O. pauciseptum *Hall*

[1] Schoharie county, exact locality not known.

Pteropoda

35 Conularia pyramidalis *Hall*[1]

Trilobita

36 Bronteus barrandii *Hall*[1]
37 Proetus protuberans *Hall*[1]
38 Dalmanites pleuroptyx (*Green*)
39 D. micrurus (*Green*)
40 ? Lichas pustulosus *Hall*[1]

Ostracoda

41 Beyrichia oculina *Hall*[1]

F Fossils of the New Scotland beds of the Schoharie region

Corals

1 Streptelasma strictum *Hall*
2 Aulopora schohariae *Hall*
3 A. tubula *Hall*
4 Michelinia lenticularis *Hall*
5 Favosites helderbergiae *Hall*

Bryozoa

6 Monotrypa ? helderbergiae *Hall*
7 Orthopora rhombifera (*Hall*)
8 Callotrypa macropora (*Hall*)
9 Phaenopora tenuis (*Hall*)[1]
10 Fenestella hestia *Hall*
11 Ichthyorachis nereis *Hall*

Crinoidea

12 Mariacrinus stoloniferus *Hall*
13 Platycrinus tentaculatus *Hall*
14 Brachiocrinus nodosarius *Hall*
15 Aspidocrinus scutelliformis *Hall*
16 A. callosus *Hall*
17 A. digitatus *Hall*
18 Coronocrinus polydactylus *Hall*
19 Dictyocrinus squamifer *Hall*

Brachiopoda

20 Lingula perlata *Hall*
21 L. rectilatera *Hall*
22 L. spathata *Hall*
23 Rhipidomella oblata *Hall*
24 R. eminens *Hall*
25 Dalmanella perelegans *Hall*
26 D. subcarinata *Hall*
27 Bilobites varicus (*Conrad*)
28 Strophonella headleyana *Hall*
29 S. cavumbona *Hall*
30 S. punctulifera (*Conrad*)
31 Stropheodonta becki *Hall*
32 Orthothetes woolworthanus *Hall*
33 Leptaena rhomboidalis (*Wilckens*)
34 Spirifer cyclopterus *Hall*
35 Delthyris perlamellosa (*Hall*)
36 Spirifer macropleura (*Conrad*)
37 Cyrtina dalmani (*Hall*)
38 Trematospira multistriata *Hall*

[1] Schoharie county, exact locality not known.

39 Nucleospira ventricosa *Hall*
40 Uncinulus nucleolatus *Hall*
41 U. abruptus *Hall*[1]
42 U. vellicatus *Hall*[1]
43 Camarotoechia altiplicata *Hall*[1]
44 C. acutiplicata *Hall*
45 Stenoschisma formosum (*Hall*)
46 Eatonia medialis (*Vanuxem*)
47 E. singularis (*Vanuxem*)
48 Anoplotheca concava (*Hall*)
49 Atrypina imbricata *Hall*
50 Meristella laevis (*Vanuxem*)[1]
51 M. bella (*Hall*)
52 M. subquadrata *Hall*
53 M. arcuata *Hall*
54 M. princeps *Hall*
55 Atrypa reticularis (*Linnaeus*)
56 Rensselaeria elliptica *Hall*[1]
57 Anastrophia verneuili (*Hall*)

Pelecypoda

58 Cypricardinia crassa *Hall*
59 Megambonia obscura *Hall*[1]
60 M. lata *Hall*[1]
61 M. oblonga *Hall*[1]
62 M. ? cordiformis *Hall*[1]
63 M. suborbicularis *Hall*[1]
64 M. rhomboidea *Hall*[1]
65 Pterinea tenuilamellata *Hall*[1]
66 P. schohariae *Hall*[1]
67 P. aequiradiata *Hall*[1]
68 P. communis *Hall*
69 P. pauciradiata *Hall*
70 P. textilis *Hall*[1]
71 P. bellula *Hall*
72 P. securiformis *Hall*

Gastropoda

73 Diaphorostoma depressum (*Hall*)
74 Strophostylus elegans *Hall*
75 Platyceras ventricosum *Conrad*
76 P. gebhardi *Conrad*
77 P. robustum *Hall*[1]
78 P. sinuatum *Hall*
79 P. trilobatum *Hall*
80 P. multisinuatum *Hall*[1]
81 P. retrorsum *Hall*[1]
82 P. retrorsum abnorme *Hall*[1]
83 P. intermedium *Hall*[1]
84 P. unguiforme *Hall*[1]
85 P. sulcoplicatum *Hall*[1]
86 P. tenuiliratum *Hall*[1]
87 P. perplicatum *Hall*[1]
88 P. plicatile *Hall*[1]
89 P. platystoma *Hall*[1]
90 P. platystoma alveatum *Hall*[1]
91 P. bisulcatum *Hall*[1]
92 P. pileiforme *Hall*[1]
93 P. perlatum *Hall*[1]
94 P. spirale *Hall*[1]
95 P. incile *Hall*[1]

[1] Schoharie county, exact locality not known.

96 Platyceras plicatum (*Conrad*)[1]
97 P. elongatum *Hall*[1]
98 P. elongatum ? *var.* *Hall*[1]
99 P. pyramidatum *Hall*[1]
100 P. arcuatum *Hall*[1]

Cephalopoda

101 Orthoceras helderbergiae *Hall*
102 O. perstriatum *Hall*
103 O. rude *Hall*
104 O. pauciseptum *Hall*

Pteropoda

105 Conularia pyramidalis *Hall*[1]
106 C. huntiana *Hall*[1]

Trilobita

107 Phacops logani *Hall*
108 Dalmanites pleuroptyx (*Green*)
109 D. micrurus (*Green*)
110 D. tridens *Hall*
111 D. nasutus (*Conrad*)
112 Lichas bigsbyi *Hall*
113 L. pustulosus *Hall*
114 Ceratocephala tuberculata (*Conrad*)[1]
115 Dicranurus hamatus *Conrad*[1]

G Fossils of the Becraft limestone of the Schoharie region

Crinoidea

1 Aspidocrinus scutelliformis *Hall*
2 Mariacrinus macropetalus *Hall*

Pteropoda

3 Tentaculites elongatus *Hall*

Brachiopoda

4 Rhipidomella assimilis *Hall*
5 Schizophoria multistriata *Hall*
6 Spirifer concinnus *Hall*
7 Stenoschisma formosum (*Hall*)
8 Camarotoechia ventricosa *Hall*
9 Uncinulus campbellanus *Hall*
10 U. nobilis *Hall*[1]
11 Meristella princeps *Hall*
12 Atrypa reticularis (*Linnaeus*)
13 Rensselaeria aequiradiata (*Conrad*)
14 Sieberella pseudogaleata (*Hall*)

Pelecypoda

15 Avicula subequilatera *Hall*[1]

Gastropoda

16 Holopea ? elongata *Hall*
17 Platyceras obesum *Hall*
18 P. clavatum *Hall*[1]
19 P. curvirostrum *Hall*[1]
20 P. agreste *Hall*[2]
21 Pleurotomaria labrosa *Hall*
22 Euomphalus disjunctus *Hall*
23 Bucania profunda *Hall*
24 Strophostylus ? rotundatus *Hall*[2]

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[1] Schoharie county, exact locality not known.
[2] Carlisle, Schoharie county.

Additional species from the Lower Helderberg series of the Schoharie region, the exact horizon of which is not given. Most of the species are probably from the New Scotland beds.

Corals

1 Aulopora elongata *Hall*
2 Vermipora serpuloides *Hall*
3 V. robusta *Hall*
4 Favosites sphaericus *Hall*
5 F. proximus *Hall*

Bryozoa

6 Monotrypa colliculata (*Hall*)
7 M. monticulata (*Hall*)
8 Chaetetes (Monotrypella) ? arbusculus (*Hall*)
9 Monotrypella ? abrupta (*Hall*)
9 M. ? abrupta (*Hall*)
10 Lioclema ponderosum (*Hall*)
11 Fistulipora ? triloba *Hall & Simpson*
12 F. ? crassa (*Hall*)
13 F. torta (*Hall*)
14 F. distans (*Hall*)
15 Ceramopora ? maculata *Hall*
16 Paleschara ? dissimilis (*Hall*)
17 Polypora lilaea *Hall*
18 Ischadites squamifer *Hall*

Pteropoda

19 Tentaculites elongatus *Hall*

Trilobita

20 Cyphaspis coelebs *Hall & Clarke*

H Fossils of the Oriskany bed of the Schoharie region

Brachiopoda

1 Hipparionyx proximus *Vanuxem*[1]
2 Rhipidomella musculosa *Hall*[1]
3 Stropheodonta magniventra *Hall*[1]
4 S. magnifica *Hall*[1]
5 S. linckiaeni *Hall*
6 Leptaena rhomboidalis ventricosa *Hall*[1]
7 Chonostrophia complanata *Hall*[1]
8 Spirifer murchisoni *Castelnau*
9 S. arenosus (*Conrad*)
10 Metaplasia pyxidata *Hall*[1]
11 Meristella lata *Hall*[1]
12 Eatonia peculiaris (*Conrad*)
13 Camarotoechia oblata *Hall*[1]
14 C. pleiopleura (*Conrad*)[1]
15 C. barrandei *Hall*[1]
16 Plethorhyncha fitchana *Hall*[1]
17 Leptocoelia flabellites (*Conrad*)[1]
18 Rensselaeria ovoides (*Eaton*)[1]
19 Megalanteris ovalis *Hall*[1]

Pelecypoda

20 Avicula textilis arenaria *Hall*[1]
21 A. gebhardi *Conrad*[1]

[1] Schoharie county, exact locality not known.

22 Megambonia bellistriata *Hall*[1]
23 M. lamellosa *Hall*[1]
24 Palaeopinna flabellum *Hall*

Gastropoda

25 Diaphorostoma ventricosum *Conrad*[1]
26 Strophostylus expansus *Conrad*[1]
27 Platyceras tortuosum *Hall*[1]
28 P. nodosum *Conrad*[1]
29 P. subnodosum *Hall*[1]
30 Cyrtolites ? expansus *Hall*[1]

Pteropoda

31 Conularia lata

Cephalopoda

32 Orthoceras arenosum *Hall*

I Fossils of the Schoharie grit

A large number of specimens described from the Schoharie grit in the *Palaeontology of New York,* were obtained from outcrops near Clarksville and Knox in Albany county. At Clarksville, and for several miles in that vicinity, are found the best exposures of the formation. It consists of "a very impure limestone, which weathers at the surface to a dark buff spongy sandrock, containing an abundance of characteristic fossils."[2] It is quite sharply separated from the Esopus, but grades upward into the Onondaga. Of the following list only those starred (*) have been listed from the Schoharie region. Those marked with a dagger (†) pass upward into the Onondaga limestone or higher. The double dagger (‡) indicates that the species is also known from the Decewville beds of Canada.

Bryozoa

1 Ptiloporina sinistralis (*Hall & Simpson*)
2 Ischadites bursiformis *Hall*

Brachiopoda

3 Lingula ceryx *Hall*
4 Crania aurora *Hall*
5 Pholidops areolata *Hall*
6 Rhipidomella peloris *Hall*
7 *Rh. alsa *Hall*
8 *Rh. mitis *Hall*
9 ‡*†Orthothetes pandora (*Billings*)
10 ‡†Leptaena rhomboidalis (*Wilckens*)
11 ‡†Stropheodonta demissa (*Conrad*)
12 S. alveata *Hall*
13 S. callosa *var. Hall*

[1] Schoharie county, exact locality not known.
[2] Darton, N. H. N. Y. State Geol. 13th Rep't. 1894. 1:243–44.

14 *Stropheodonta parva *Hall*
15 *S. crebristriata (*Conrad*)
16 ‡†*S. inaequiradiata *Hall*
17 †*S. patersoni *Hall*
18 ‡†*S. hemispherica *Hall*
19 ‡†*S. perplana (*Conrad*)
20 ‡†*Strophonella ampla *Hall*
21 ‡†*Chonetes hemisphericus *Hall*
22 †*Spirifer duodenarius (*Hall*)
23 †*S. macer *Hall*
24 †*S. raricosta (*Conrad*)
25 †S. grieri *Hall*
26 †*Reticularia fimbriata (*Conrad*)
(Also in the Oriskany)
27 †*Cyrtina biplicata *Hall*
28 †*C. hamiltonensis *Hall*
29 †*Nucleospira concinna *Hall*
30 †*Meristella nasuta (*Conrad*)
31 †*M. doris *Hall*
32 ‡*Atrypa reticularis impressa *Hall*
33 ‡†*Pentamerella arata (*Conrad*)
34 ‡†Amphigenia elongata (*Vanuxem*)
35 ‡†*Centronella glans-fagea (*Hall*)

Pelecypoda

36 Lyriopecten parallelodontus *Hall*
37 *Actinopteria eximia *Hall*
38 *Plethomytilus arenaceus *Hall*
39 *Mytilarca pyramidata *Hall*
40 *Modiomorpha schohariae *Hall*
41 *M. regularis *Hall*
42 *M. putilla *Hall*
43 *Goniophora perangulata (*Hall*)
44 *G. ? alata *Hall*
45 *Grammysia praecursor *Hall*
46 †*Conocardium cuneus (*Conrad*)
47 *Panenka dichotoma *Hall*
48 *Schizodus ? fissus *Hall*
49 ‡*Cypricardinia planulata (*Conrad*)

Gastropoda

50 *Diaphorostoma aplatum *Hall*
51 *Strophostylus unicus *Hall*
52 *Callonema (?) primaevum *Hall*
53 *Cyclonema doris *Hall*
54 ‡*Loxonema ? subattenuatum *Hall*
55 †*L. robustum *Hall*
56 *L. solidum *Hall*
57 *Straparollus inops *Hall*
58 †*S. clymenioides *Hall*
59 †*Pleurotomaria arata *Hall*
60 *Bellerophon curvilineatus *Conrad*
61 †*B. pelops *Hall*

Pteropoda

62 ‡*Hyolithus ligea *Hall*
63 *H. principalis *Hall*

Cephalopoda

64 *Orthoceras pelops *Hall*
65 O. zeus *Hall*

66 *Orthoceras masculum *Hall*
67 *O. fluctum *Hall*
68 *O. cingulum *Hall*
69 *O. tantalus *Hall*
70 *O. vastator *Hall*
71 *O. luxum *Hall* (most common and characteristic)
72 *O. oppletum *Hall*
73 *O. procerus *Hall*
74 *O. tetricum *Hall*
75 *O. collatum *Hall*
76 *O. stylus *Hall*
77 *O. medium *Hall*
78 *O. pravum *Hall*
79 *O. pervicax *Hall*
80 *O. carnosum *Hall*
81 *O. rarum *Hall*
82 *O. erion *Hall*
83 †*O. thoas *Hall*
84 *O. multicinctum *Hall*
85 *O. duramen *Hall*
86 *Gomphoceras fax *Hall*
87 *G. illaenus *Hall*
88 G. clavatum *Hall*
89 †*G. absens *Hall*
90 *G. beta *Hall*
91 *G. rude *Hall*
92 *G. ? crucifer *Hall*
93 †*Cyrtoceras morsum *Hall*
94 †*C. eugenium *Hall*
95 *C. aemulum *Hall*
96 *C. jason *Hall*
97 *Gyroceras spinosum (*Conrad*)
98 *G. validum *Hall*
99 *Trochoceras clio *Hall*
100 *T. discoideum *Hall*
101 T. biton *Hall*
102 *T. eugenium *Hall*
103 T. orion *Hall*
104 *T. barrandei *Hall*
105 *T. pandion *Hall*
106 *T. obliquatum *Hall*
107 *T. expansum *Hall*

Trilobita

108 ‡*Calymmene platys *Green*
109 †*Phacops cristata *Hall*
110 †*Hausmannia concinna *Hall & Clarke*
111 Dalmanites (Coryephalus) regalis *Hall*
112 ‡†*D. (Synphoria) anchiops *Hall*
113 †*D. (Synphoria) anchiops *var.* armatus *Hall*
114 *D. (Synphoria) anchiops *var.* sobrinus *Hall & Clarke*
115 †Acidaspis callicera *Hall & Clarke*
116 †*Lichas (Terataspis) grandis *Hall*
117 †L. (Conolichas) hispidus *Hall & Clarke*
118 *Proetus conradi *Hall*
119 *P. angustifrons *Hall*
120 *P. hesione *Hall*
121 ‡†*P. crassimarginatus *Hall*
122 †*Cordania arenicolus *Hall and Clarke*
123 †*Cyphaspis minuscula *Hall*

J Fossils of the Onondaga limestone of the Schoharie region

Anthozoa

1 Favosites basalticus *Goldfuss*
2 F. epidermatus *Rominger*
3 F. hemisphericus distortus *Hall*
4 Zaphrentis prolifica *Billings*
5 Cyathophyllum robustum *Hall*

Bryozoa

6 Monotrypa tabulata (*Hall*)
7 Thamniscus multiramus *Hall*
8 Ptiloporina pinnata (*Hall & Simpson*)

Brachiopoda

9 Orthothetes pandora (*Billings*)
10 Leptaena rhomboidalis (*Wilckens*)
11 Stropheodonta inaequiradiata *Hall*
12 S. patersoni *Hall*
13 S. hemispherica *Hall*
14 Strophonella ampla *Hall*
15 Productella navicella *Hall*
16 Spirifer duodenarius (*Hall*)
17 S. raricosta *Conrad*
18 S. acuminatus (*Conrad*)
19 S. divaricatus *Hall*
20 Reticularia fimbriata (*Conrad*)
21 Cyrtina hamiltonensis *Hall*
22 Athyris spiriferoides (*Eaton*)
23 Meristella nasuta (*Conrad*)
24 Pentagonia unisulcata (*Conrad*)
25 Atrypa reticularis (*Linné*)
26 A. pseudomarginalis *Hall*
27 Pentamerella arata (*Conrad*)
28 Amphigenia elongata (*Vanuxem*)
29 Collospira camilla *Hall*

Pelecypoda

30 Aviculopecten pectiniformis (*Conrad*)

Gastropoda

31 Platyceras dumosum *Conrad*
32 P. nodosum *Conrad*
33 P. undatum *Hall*
34 P. crassum *Hall*
35 Diaphorostoma lineatum (*Conrad*)
36 D. unisulcatum (*Conrad*)
37 D. turbinatum (*Hall*)
38 Euomphalus decewi *Billings*
39 Phanerotinus laxus *Hall*

Pteropoda

40 Tentaculites scalariformis *Hall*

Cephalopoda

41 Cyrtoceras eugenium *Hall*
42 C. citum *Hall*
43 C. jason *Hall*
44 Gyroceras trivolve (*Conrad*)
45 G. matheri (*Conrad*)
46 G. undulatum (*Vanuxem*)
47 G. paucinodum *Hall*

Trilobita

48 Dalmanites (Coronura) diurus (*Green*)
49 D. (Coronura) myrmecophorus (*Green*)
50 D. (Odontocephalus) selenurus (*Eaton*)
51 D. calypso *Hall*
52 D. (Coronura?) macrops *Hall*
53 Lichas (Conolichas) eriopis *Hall*
54 L. (Ceratolichas) gryps *Hall & Clarke*
55 L. (Ceratolichas) dracon *Hall & Clarke*
56 Proetus folliceps *Hall & Clarke*
57 P. clarus *Hall*

K Fossils of the Marcellus shales and calcareous beds of the Schoharie region

1 Chonetes mucronatus *Hall*
2 Strophalosia truncata *Hall*
3 Liorhynchus mysia *Hall*
4 L. limitaris (*Vanuxem*)
5 Lunulicardium marcellense *Vanuxem*
6 Tentaculites gracilistriatus *Hall*
7 Styliolina fissurella *Hall*
8 Orthoceras vicinus *Hall*
9 O. thestor *Hall*
10 O. subulatum *Hall* ?
11 Bactrites clavus *Hall*
12 Nautilus oriens *Hall*

L Fossils of the Agoniatites limestone of the Schoharie region

1 Liorhynchus mysia *Hall*
2 Panenka ventricosa *Hall*
3 Lunulicardium rude *Hall*
4 Orthoceras fustis *Hall*
5 O. marcellense *Vanuxem*
6 Cyrtoceras alternatum *Hall*
7 Gomphoceras conradi *Hall*
8 G. oviforme *Hall*
9 Goniatites (Agoniatites) expansus *Vanuxem*
10 G. (Parodiceras) discoideus *Conrad*
11 Nautilus (Discites) marcellensis *Vanuxem*

M Fossils of the Hamilton sandstones of the Schoharie region

Brachiopoda

1 Spirifer acuminatus (*Conrad*)
2 S. granulosus (*Conrad*)
3 S. mucronatus (*Conrad*)
4 S. audaculus (*Conrad*)
5 S. tullius *Hall*
6 Chonetes coronatus (*Con.*)
7 C. deflectus *Hall*
8 C. mucronatus *Hall*
9 Orthothetes chemungensis *var.* arctostriatus *Hall*
10 Athyris spiriferoides (*Eaton*)
11 Stropheodonta perplana (*Conrad*)
12 Camarotoechia congregata (*Conrad*)
13 C. prolifica (*Hall*)
14 Liorhynchus multicostum *Hall*

15 Orbiculoidea (Lindstroemella) aspidium *Hall & Clarke*
16 O. randalli *Hall*
17 Cryptonella (Eunella) lincklaeni *Hall*
18 Productella dumosa *Hall* ?
19 Tropidoleptus carinatus (*Conrad*)
20 Ambocoelia umbonata (*Conrad*)
21 Strophalosia truncata (*Hall*)
22 Cyrtina hamiltonensis *Hall*
23 Oehlertella exilis (*Hall*)
24 Lingula punctata *Hall*
25 L. densa *Hall*
26 Dignomia alveolata *Hall*
27 Centronella glaucia *Hall*

Pelecypoda

28 Aviculopecten formio *Hall*
29 A. princeps (*Conrad*)
30 A. phorus *Hall*
31 A. fasciculatus *Hall*
32 A. idas *Hall*
33 Lyriopecten interradiatus *Hall*
34 Pterinopecten vertumnus *Hall*
35 P. undosus *Hall*
36 Pterinea flabellum (*Conrad*)
37 Actinopteria boydi (*Conrad*)
38 Glyptodesma erectum (*Conrad*)
39 Liopteria bigsbyi *Hall*
40 L. mitchelli *Hall*
41 L. troosti *Hall*
42 L. leai *Hall*
43 L. greeni *Hall*
44 Leptodesma rogersi *Hall*
45 Plethomytilus oviformis *Conrad*
46 Gosseletia triquetra (*Conrad*)
47 Modiomorpha arcuata *Hall*
48 M. mytiloides (*Conrad*)
49 M. subalata (*Conrad*)
50 M. concentrica (*Conrad*)
51 Goniophora hamiltonensis *Hall*
52 G. rugosa *Conrad*
53 G. glauca *Hall*
54 G. truncata *Hall*
55 Cypricardella gregaria *Hall*
56 C. tenuistriata *Hall*
57 C. complanata *Hall*
58 Microdon bellistriatus (*Conrad*)
59 Nucula randalli *Hall*
60 N. bellistriata (*Conrad*)
61 Nuculites cuneiformis *Conrad*
62 N. triqueter *Conrad*
63 N. oblongatus *Conrad*
64 Leda diversa *Hall*
65 L. brevirostris *Hall*
66 L. obscura *Hall*
67 Palaeoneilo constricta (*Conrad*)
68 P. maxima (*Conrad*)
69 P. emarginata (*Conrad*)
70 P. perplana *Hall*
71 P. tenuistriata *Hall*
72 Macrodon hamiltoniae *Hall*

73 Nyassa subalata *Hall*
74 N. recta *Hall*
75 N. arguta *Hall*
76 Grammysia bisulcata (*Conrad*)
77 G. erecta *Hall*
78 G. circularis *Hall*
79 G. obsoleta *Hall*
80 G. alveata (*Conrad*)
81 G. lirata *Hall*
82 G. globosa *Hall*
83 G. zonata *Hall*
84 G. arcuata (*Conrad*)
85 G. constricta *Hall*
86 Sphenotus truncatus (*Conrad*)
87 S. cuneatus (*Conrad*)
88 S. subtortuosus *Hall*
89 S. solenoides *Hall* (?)
90 Schizodus appressus (*Conrad*)
91 Prothyris lanceolata *Hall*
92 Tellinopsis subemarginata (*Conrad*)
93 Cimitaria elongata (*Conrad*)
94 Pholadella radiata (*Conrad*)
95 Orthonota undulata *Conrad*
96 O. carinata *Conrad*
97 O. ensiformis *Hall*
98 O. (?) parvula *Hall*
99 Palaeosolen siliquoideus *Hall*
100 Elymella levata *Hall*
101 Protomya oblonga *Hall*
102 Limoptera macroptera (*Conrad*)
103 Paracyclas lirata (*Conrad*)

Gastropoda

104 Pleurotomaria filitexta *Hall*
105 P. capillaria *Conrad*
106 P. sulcomarginata *Conrad* (?)
107 P. trilix *Hall*
108 Bellerophon patulus *Hall*
109 B. rudis *Hall*
110 B. otsego *Hall*
111 B. crenistriatus *Hall*
112 Cyrtonella mitella *Hall*
113 C. pileolus *Hall*

Pteropoda

114 Coleolus tenuicinctus *Hall*
115 Tentaculites bellulus *Hall*
116 Conularia continens *var.* rudis *Hall*

Cephalopoda

117 Nautilus bucinum *Hall*
118 Orthoceras crotalum *Hall*

Trilobita

119 Phacops rana (*Green*)
120 Homalonotus dekayi (*Green*)
121 Cryphaeus boothi *var.* calliteles *Green*
122 Proetus rowi (*Green*)

Incertae sedis

123 Spirophyton velum (*Vanuxem*)

N Fossils of the Ithaca and the Sherburne beds of the Schoharie region

Brachiopoda

1 Orbiculoidea *cf.* media (*Hall*)
2 Spirifer mucronatus (*Con.*)
3 S. mesastrialis *Hall*
4 S. tullius *Hall*
5 S. fimbriatus (*Con.*)
6 Tropidoleptus carinatus (*Con.*)
7 Ambocoelia umbonata (*Con.*) ?
8 Athyris spiriferoides (*Eaton*)

Pelecypoda

9 Orthonota undulata *Con.*
10 Microdon bellistriatus *Con.*
11 M. gregaria *Hall*
12 Sphenotus truncatus (*Con.*)
13 S. cuneatus (*Con.*)
14 Goniophora *sp.*
15 Schizodus appressus *Con.*
16 S. *cf.* ellipticus *Hall*
17 Paracyclas tenuis *Hall*
18 Grammysia (Sphenomya) cuneata *Hall* (?)
19 G. subarcuata *Hall*
20 Palaeoneilo *cf.* plana *Hall*
21 P. emarginata (*Con.*)
22 Liopteria bigsbyi *Hall*
23 L. dekayi *Hall*

Gastropoda

24 Bellerophon patulus *Hall*
25 B. acutilira *Hall* (?)
26 Cyrtolites (Cyrtonella) pileolus *Hall* (?)
27 Tentaculites *sp.*

NOTE. The foregoing lists will serve to indicate to the student the species that may reasonably be looked for in the different Schoharie formations. It is not desired to convey the impression that all the fossils named have been recorded from this locality.

Chapter 8

PHYSIOGRAPHY OF THE SCHOHARIE REGION

We have hitherto spoken of the hills of the Schoharie region as the most dominant topographic feature of the district. And so they appear when looked at from the point of view of the ordinary observer in the valley bottoms. To the inhabitants of this region, since the days of its occupancy by the Indian, the broad bottom lands margining the principal streams have been the chief attraction, partly because of their great fertility, and partly because of the ease with which communication between settlements could be established on the level country. The hillsides and uplands are the last conquered portion of the region, and even now have only been partially subjugated. The difficulty of maintaining the roads, which of necessity follow the streams by which the hillsides are dissected and which are therefore subject to continual washouts by strong rains or by the streams themselves, was a potent factor in the retardation of the hillside settlement. This difficulty can be readily appreciated if one follows the little frequented, and therefore poorly mended roads which lead up over some of the hillsides, or the abandoned roads which not infrequently have become stream beds. Settlements being, then, in the valley bottoms, or more sparingly along the valleys of streams laterally incising the hills, it is not surprising that the Schoharie region is generally conceded to have a mountainous topography. Yet if one climbs to the summits of some of the higher hills, where a comprehensive view of the uplands may be obtained, the surprise of a moderately undulating high plateau is met with. So uniform is the altitude to which the apparently irregular hilltops rise, and so relatively inconspicuous are the incisions in this upland, that, provided the observer stands high enough, the sky line will appear a nearly level one. This is specially noticed if one looks from a sufficient altitude across the valley to the opposite line of hills. Only one

great exception to this evenness of the upland plateau is noticeable to the south where the high peaks of the Catskills rise abruptly above the general level.[1] A prolonged inspection of the country from such a vantage point, impresses the beholder with the fact that it is the plateau or even upland which is the dominant topographic feature of the region, and that the hills seen from the low ground, are merely the carved edges of this plateau where it has been deeply incised by the three principal streams of the region, the Schoharie kill, the Cobleskill and the Fox kill. The deeply sunken valleys of these streams are, next to the plateau, the most prominent topographic element of the landscape, and one might not inaptly emphasize this fact by speaking of the region as a valley country rather than a hill country.

In the vicinity of Middleburg and northward the average altitude to which the hills rise is 2100 feet, though westward in Petersburg mountain the elevation is as high as 2300 feet. Northward from Middleburg the level falls to about 2000 feet and still farther north to 1900, and then 1800 feet. The hills immediately bordering the larger valleys rise to less than the average hight as might be expected. Thus West mountain is 1200 feet, Dann's mountain nearly 1400 feet and Sunset hill 1600 feet. Northward there is a gradual descent of the upland region, the average upland elevation being little over 1000 feet in the Mohawk region.

[1] One of the best localities for observing the features here described is on the summit of Moheganter hill, which rises to the south of Middleburg, apparently hemming in the valley on the south as seen from Schoharie. About three miles southwest of Middleburg, on the south side of the river, a small stream has cut the northwestern face of Moheganter hill, and here at the schoolhouse of district no. 11 a road branches off from the main Schoharie valley road and climbs the hill. Behind the house of Mr John Vroman, the second inhabited house on the road, is a bare knoll which rises above 1900 feet A.T. From the summit of this knoll a splendid view of the even upland, the Catskills and the deep Schoharie valley may be obtained. Other good views are found farther along on the road. Interesting outcrops of Hamilton, Sherburne and Oneonta strata are found along this highway.

Plate 21

Krum's falls; 8 miles south of Schoharie

It has already been noted that the strata of this region dip southward at about 135 feet to the mile, or approximately one foot in 40. Thus it appears that the even upland surface, which in fact gently rises southward, bevels across the strata, the surface and dip being discordant, and the plateau therefore not due to the strata composing it. In other words the surface of the upland is an erosion surface which passes obliquely across the strata, instead of being determined by a hard stratum at that level, which might have largely prevented the degradation below that general horizon. If thus the level is an erosion level why did it stop so generally at a uniform hight, so as to give the appearance of a level plateau, when this checking of erosion was not determined by a uniform hard stratum which everywhere protected the summits at that level? The only adequate answer to that question is: that when erosion had reached the level in question, it could go no farther because *at that time the base level of erosion practically had been reached.* In other words the sea level at the period during which the ancient surface was worn down to the plateau level, was about 2000 feet higher in this region than now, or the land stood so much lower with reference to the sea. All the valleys which cut below that level were made subsequently to it, when a relative change in the land and sea levels took place, the former rising or the latter falling. The more or less even surface near sea level, which characterized the end of this earlier cycle of denudation, was due wholly to the working of subaerial agencies and not to marine erosion, there being absolutely no evidence of the occupancy of this region by the sea, in Postpaleozoic time. Thus this approximate plane of erosion falls under the type to which the name "peneplain" is applied by physiographers, while the high peaks of the Catskills which dominate this peneplain fall under the type known as "monadnocks." As just stated, the Schoharie and other valleys cut into this upland are of later origin and therefore belong to the present cycle of erosion, of which they represent the initial effects.

Let us now inquire into the condition of the early surface of the region and the method of erosion which has produced the peneplain surface, after which we may discuss more in detail the erosion accomplished during the present cycle.

The Paleozoic coastal plain. In discussing the origin of the various geologic formations of this region it has already been pointed out that each of the more extensive ones at any rate must have been deposited over the entire region, overlapping the earlier ones, and extending up on the old shore which was then formed by the Precambric and early Paleozoic rocks. The later formations specially, such as the Hamilton, Sherburne, Oneonta and Catskill sandstones were made of material directly derived from the crystalline rocks of the Adirondacks and Laurentides, and the metamorphic sediments of the Appalachian old land. It is easily seen that there is no other likely source of these sediments and that hence each one must in turn have overlapped the preceding ones and come to rest directly on the shelving surface of the old land. With their present dip of 135 feet to the mile the base of the first red sandstones of this region (the Oneonta) would be carried 5000 feet above the sea in the region of the Mohawk and more than 15,000 feet in the central Adirondack region. As the present dip of the strata is probably much greater than the original dip of deposition and as the Adirondack region has suffered much erosion in Postpaleozoic time, there is no reason to believe that the Adirondacks were wholly covered by the Oneonta and Catskill strata, though they probably reached far up on them. A clear comprehension of the former extent of the strata of this region helps one to realize the enormous amount of erosion which the region has suffered since Paleozoic time, as well as the length of the time consumed in the process. Compared with this tremendous erosion the formation of the Schoharie valley during the present cycle of erosion is a very insignificant result, scarcely more than a scratch on the surface of the ancient peneplain.

Development of drainage lines. After the coastal plain of Paleozoic strata emerged, by the southward and westward retreat of

the seashore, a simple type of drainage soon became established on it. Those streams which had formerly brought the material from which the coastal plain was built, now continued their way across this plain, following the slope of the land, and entered the sea somewhere in the region of the present Mississippi valley. To simple streams of this type the name "consequent streams" is applied, since they are consequent on the slope of the surface on which they originate. Streams of this type cut downward, making valleys for themselves, which in depth are proportional to the distance from shore, the slope and hardness of the strata and the velocity of the current. At first these streams have no tributaries, but these are gradually formed out of the gullies which are cut into the sides of the valley of the consequent stream. Such streams, not controlled by original structural features, form the type denominated "insequent streams." Some of these will invariably outstrip the others, and they will generally be the ones near the old land, since here the river is higher above the sea than elsewhere below and can cut its channel deeper; hence the tributary insequents would have a greater slope and therefore cut deeper trenches. In time these insequents will outstrip their brethren which are farther down the course, and so develop into the "subsequent" type, which near the upper end of the coastal plain opens up a valley or *inner lowland* by removing the strata immediately adjacent to the old land. The valley thus formed will have on one side the hard crystallines of the old land, while on the other there will be most generally a cliff of the sedimentaries. The topographic element thus formed has come to be known as a *cuesta*[1] and may be defined as a portion of a coastal plain which has been separated by the normal processes of stream erosion from the old land against which it originally lapped. The essential features of the normal cuesta are a gentle surface slope to the sea, and a steep escarpment or "inface," the precipitousness of which will be in proportion to the resistance of the sur-

[1]A name of Spanish origin, and proposed by Prof. W. M. Davis for the topographic type described. Pronounce kwesta.

face stratum and the weakness of the underlying beds. Between the inface of the cuesta and the old land lies the stripped belt, or "inner lowland" which has been opened up by the subsequent streams. The diagrams [fig. 209] show the beginning of the drainage system on a coastal plain and [fig. 210] the completed simple cuesta. It will be perceived that the inner lowland is widened by the gradual seaward retreat of the inface of the cuesta. By this process the altitude above sea level, of the upper edge of the

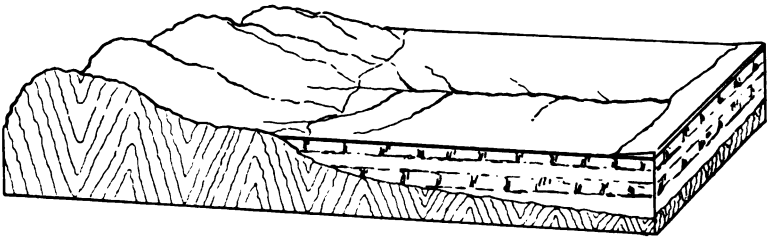


Fig. 209 Diagram of simple coastal plain after elevation, showing simple consequent drainage

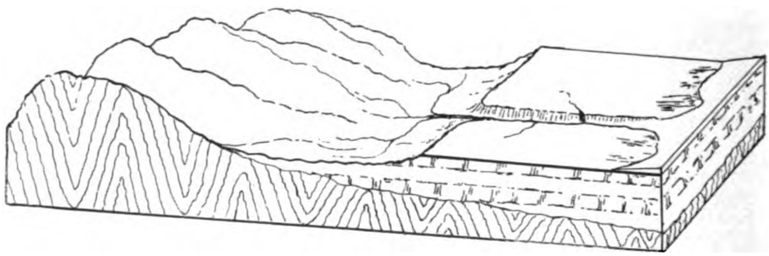


Fig. 210 Coastal plain after erosion and formation of cuesta topography

cuesta, gradually diminishes owing to the gentle seaward dip of the strata. At the same time the hight of the inface of the cuesta may increase, for by its seaward retreat lower and lower strata are uncovered, the edges of which become incorporated in the basal portion of the inface of the cuesta. As before stated, if the upper layer is very resistant, while the basal strata are easily eroded, the inface of the cuesta will be steep and rugged. This is essentially the case with the front of the Helderberg escarpment at the Indian Ladder, which for purposes of illustration may be compared with a normal cuesta front or inface, while the Hudson valley between it and the old land of the Taconic region repre-

sents the inner lowland. As will be seen presently this region does not represent a cuesta in its primitive condition, but rather a revived cuestalike topography.

If, with continued recession of the inface of the cuesta, and a widening of the inner lowland, a second hard stratum is discovered beneath the soft one, the inner lowland may for a time be

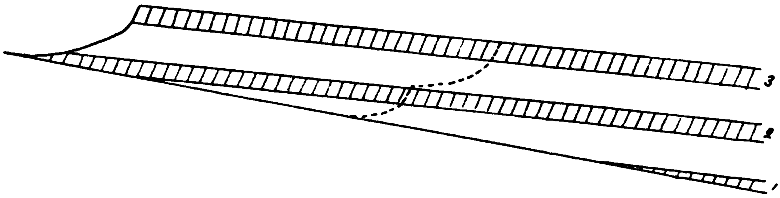


Fig. 211 Diagram of simple escarpment formed by exposed hard stratum (3) overlying a soft stratum

floored by this stratum. Gradually however this stratum will also be cut through and if another softer one is discovered beneath, a second inface will soon come into existence, the cuesta now becoming a double one [fig. 211, 212]. The retreat of both cliffs may be uniform or there may be a differential retreat. In the first case the two cliffs will never be far apart, in the second

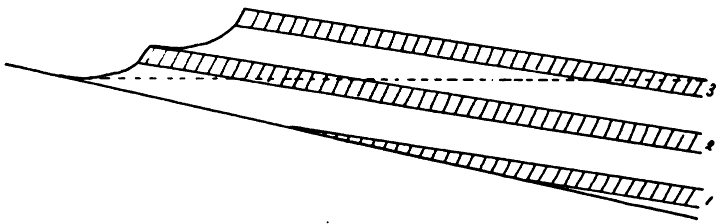


Fig. 212 Compound escarpment produced by two hard strata after recession to dotted line in fig. 211

case they will either approach each other, the lower one gaining on the upper, or become more and more separated, the upper one retreating faster. Cliffs of differential retreat are well illustrated by the terraces on West hill (plate 1).

Where there is a regular alternation of hard and soft strata several times repeated, the cuesta front will be terraced, but it will be essentially one cuesta front or inface, just as the eastern face of West hill is a single one, though composed of several

terraces. This we may assume to be the norm for it is not likely, except in rare cases, that the upper cliff will retreat so rapidly that the space between the two becomes broad enough to have the characters of a second inner lowland, separating two cuestas. Conditions of multiple cuestas exist, as for example the two cuestas of the ancient (Postpaleozoic) coastal plains of central

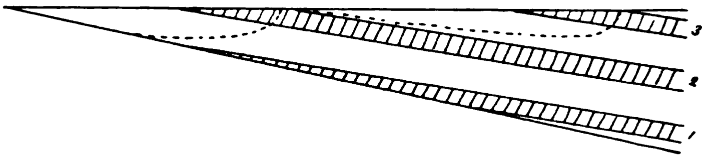


Fig. 213 Outcrops of hard strata (2 & 3) after peneplenation to dotted line in fig. 212

England, described by Davis[1], or the Niagara and Onondaga cuestas of western New York.[2] Such conditions are explainable in one of two ways. Peneplenation obliquely across the strata and recarving of the valleys on the softer beds. This appears to have been the method which has given rise to the repeated cuestas of

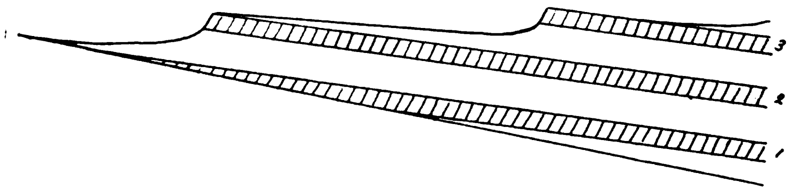


Fig. 214 Two escarpments resulting from erosion on soft strata after peneplenation (compare dotted lines of fig. 213)

western New York. This method is illustrated in the above diagrams [fig. 213, 214] and will be more fully discussed below. A partial elevation of the coastal plain may occur and while a cuesta topography is gradually carved out of the strata of this plain, a new coastal plain may be deposited with the older one for its shore and old land. Then on a second elevation the cuesta topography may be carved out of the later coastal plain as shown

[1] Textbook of Physical Geography.

[2] Grabau. Geology of Niagara Falls. N. Y. State Mus. Bul. 45. p. 44.

in the diagrams [fig. 215, 216]. This, according to Davis, appears to have been the origin of the cuestas of central England.

Continuous seaward retreat of the edge of a simple cuesta eventually brings the inner lowland to the point where the top of the soft stratum passes below the level at which erosion takes place. Then the cliff will slowly be degraded by atmospheric

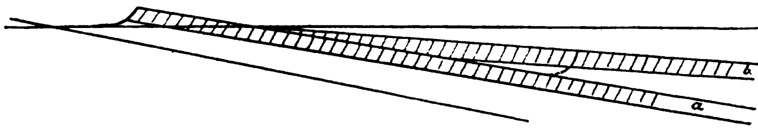


Fig. 215 Diagram showing formation of escarpment by erosion of soft stratum under *a*, and formation of coastal plain strata *b*

erosion till it too has been reduced to the level of erosion, when peneplenation will be accomplished [fig. 217, 218]. The same fate awaits the terraced cuesta unless a new lease of life should be given by a renewed elevation. Otherwise the lowest terrace is first doomed to extinction, the others following in succession from below upward till the whole region is peneplaned [fig. 219–221].

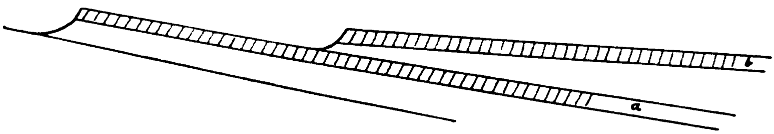


Fig. 216 Two escarpments due to subsequent erosion of soft stratum under hard stratum *b*, along dotted line in fig. 215

This condition of peneplenation can readily be recognized by the beveled appearance of the strata at the successive outcrops, the thickness decreasing toward the old land from the moment they pass out from under the protection of the overlying stratum. That this thinning is not the thinning natural to strata as we approach the old shore, is shown by the fact that the lithic character of the bed remains unchanged, which would certainly not be the case if we had reached the former shore, and furthermore by the fact that the lowest bed of each stratum is the one found at the thin end of the wedge [fig. 222], whereas if the thinning

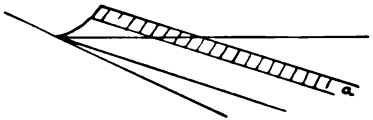


Fig. 217

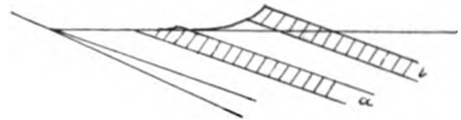


Fig. 220

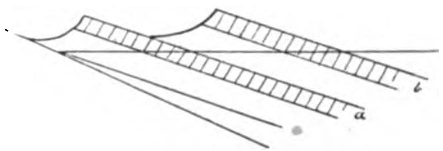


Fig. 219

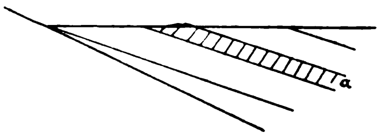


Fig. 218

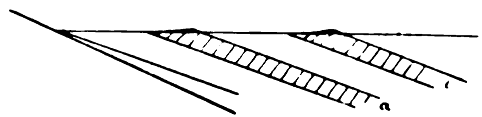


Fig. 221

Fig. 217, 218 destruction of simple, and fig. 219 221 destruction of double cuesta by peneplanation. In all these diagrams the dip of the strata is much too great. Normally it is only a few degrees.

were due to deposition on a shelving shore the thin edge should be made of the upper beds of the stratum only [fig. 223].

When elevation of the peneplain takes place streams naturally become adjusted on the softer strata and so carve out again the cuesta topography by working along the softer beds. This revived topography is not readily distinguishable at first sight from the original cuesta topography. The revived cuestas how-

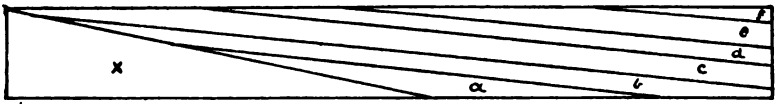


Fig. 222 Thinning away of strata by overlap on x-(*a*, *b*) and through erosion (peneplenation - *c*-*f*). In the latter case the lower portion of each bed extends beyond the upper

ever are much further removed from the old land than were their predecessors.

That this has been the history of the Helderberg and Schoharie regions seems to be indicated by the correspondence of all the features of the region with those outlined in the theoretic discussion of cuesta development on a coastal plain of the type formed by these old Paleozoic strata. The first cuesta formed

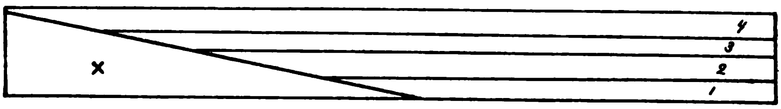


Fig. 223 Thinning of strata through overlap on x. Upper portion of each bed extends beyond the lower portion

was probably that of the Catskill and Oneonta sandstones and the inner lowland between it and the old land was probably at first somewhere north of the present Mohawk valley. As the escarpment was pushed southward and westward, lower and lower members of the Paleozoic series were discovered and the cuesta front probably began to take on the terrace form. It must be remembered that the old land at this time formed a semicircle, extending along the north and along the west and southwest. What the original drainage was can of course only be conjec-

tured, nevertheless the general direction of these ancient streams can be indicated with a fair approach to accuracy. Davis[1] has indicated some of the probable drainage lines of this early period in the Pennsylvania region and his assumptions may be regarded as expressing the conditions of that time as accurately as the present evidence will permit. After the formation of the Appalachian folds, then much more pronounced than now, the synclinal valleys were occupied by longitudinal consequent streams, which drained into lakes filling the lower basin-shaped depressions between the ridges. Some of these were drained northwestward by the master stream of the region which Davis has named the Anthracite river and which he locates not far from the present Susquehanna. This river joined the ancient Ohio, which then as now drained westward to the Mississippi gulf. Other small streams flowed from the northwestern faces of the "Nittany highland" and the "Bedford range" and likewise became tributary to the Ohio.

A feature which greatly complicated the drainage development during Mesozoic time and in fact entirely changed the normal conditions in the southwestern part of this area, was the folding of the strata into the Appalachian anticlines and synclines which took place during late Permian time, and the magnitude and extent of which may be judged of by an examination of the remnants found at present in the folded district. From the westernmost slopes of these mountains, the drainage flowed northwestward, but the drainage of the other slopes was carried along the synclinal troughs and thus the interior was deprived of this drainage, together with that of the Old Appalachian continent to the southeast. In consequence the streams flowing northwest from this newly formed mountain area were much smaller than those coming from the northeast, for the latter continued to carry the drainage of a large part of the Canadian old land into the Mississippi embayment. As a result the erosion in the northeastern region must have been much more pronounced, even

[1] Davis, William Morris. The Rivers and Valleys of Pennsylvania. Nat. Geog. Mag. v.1, no.3.

though the slopes were steeper on the southeast. It was probably not till the end of Mesozoic time that the peneplain on the sedimentary rocks was completed, the Catskills alone remaining as remnants of the higher lands which were almost entirely removed by erosion. That this peneplanation did not necessarily include the old land will be clear from the discussion of the manner of formation of the peneplain. Nevertheless we may safely assume that these harder crystalline rocks also suffered considerable erosion during the interval from the end of the Paleozoic to the beginning of the Cenozoic (Tertiary) time. Some portions indeed may actually have been reduced to peneplain condition, as was the case with the crystalline rocks of New England. Even the folds of the Appalachians were worn down till that region of varied rocks was reduced to a comparatively level portion of the great Cretacic peneplain, with the rivers lazily wandering across the region without regard to the underlying rock structure.

With the beginning of Tertiary time the whole of the northeastern continent appears to have been elevated, whereupon all drainage lines at once became revived and began actively to cut valleys in the upland plateau.

There is reason for believing that the land stood very much higher at the beginning of the Tertiary than it does at present. If the slope of the surface of the peneplain in this region was northward at that time as it is now (judging from the gradual northward decrease of altitudes) it is easy to understand how such rivers as the Schoharie could begin to flow northward, and cut a valley such as we find it, across the strata. But there is evidence which leads us to suppose that the surface of the peneplain, if not horizontal, was sloping southwestward.[1] If this was

[1]The evidence for this is found in the apparent course of the preglacial streams which carved the valleys of the present Lakes Ontario, Erie and Huron. The Tertiary consequents of this region flowed in all probability southwestward into the Mississippi gulf as did the Cretacic consequents. For a discusion of this problem see the author's Guide to the Geology of Niagara Falls, etc. and a paper entitled "Physical Geology of Central Ontario" by Dr Alfred W. G. Wilson. Can. Inst. Trans. 1901. 7:139–86.

the case the course of the Schoharie and its two branches, the Cobleskill and Fox kill, must be explained in another manner. They must then be regarded as belonging to that type of insequential drainage which eats its way backward from that valley, in this case the Mohawk river valley, which takes the place of the inner lowland in front of the normal cuesta. As these streams flow in the opposite direction to that of the principal stream of the coastal plain, to which they are nevertheless tributary, they have received the appropriate name of "obsequent" streams.

As has been shown by Chamberlin[1] the divide between the Mohawk and a westward flowing river (the Ontario) was at Little Falls N. Y. From this point the Mohawk flowed eastward as a revived subsequent stream between the old land on the north and the sediments on the south. Commencing its new term of life on a peneplain surface on which it formed the master stream of that region, it incised its bed without much selection. Moreover as the region had suffered faulting it is not surprising to find that the bed of the Mohawk does not continuously follow the outcrop of the same formation. The Mohawk joined the Hudson then as now, the latter stream at that time undoubtedly receiving a plentiful supply of tributaries from the Adirondack region, which probably stood several thousand feet higher then than now. Tributaries from the region east of the Adirondacks, which eventually carved the Champlain valley, were also received by the Hudson, though some portions of this valley were probably carved by streams flowing northward and becoming tributary to the Tertiary St Lawrence, which at that time headed near the Thousand Islands.

We must assume that during the Cretacic peneplanation the crystalline belt lying east of the present Helderbergs, which may or may not have been covered by the sediments during Paleozoic time, was planed down sufficiently to allow the Hudson to cut across it as the shortest route to the sea in Tertiary time. This

[1] Chamberlin, T. C. Preliminary Paper on the Terminal Moraine of the Second Glacial Epoch. U. S. Geol. Sur. 3d An. Rep't. p. 362.

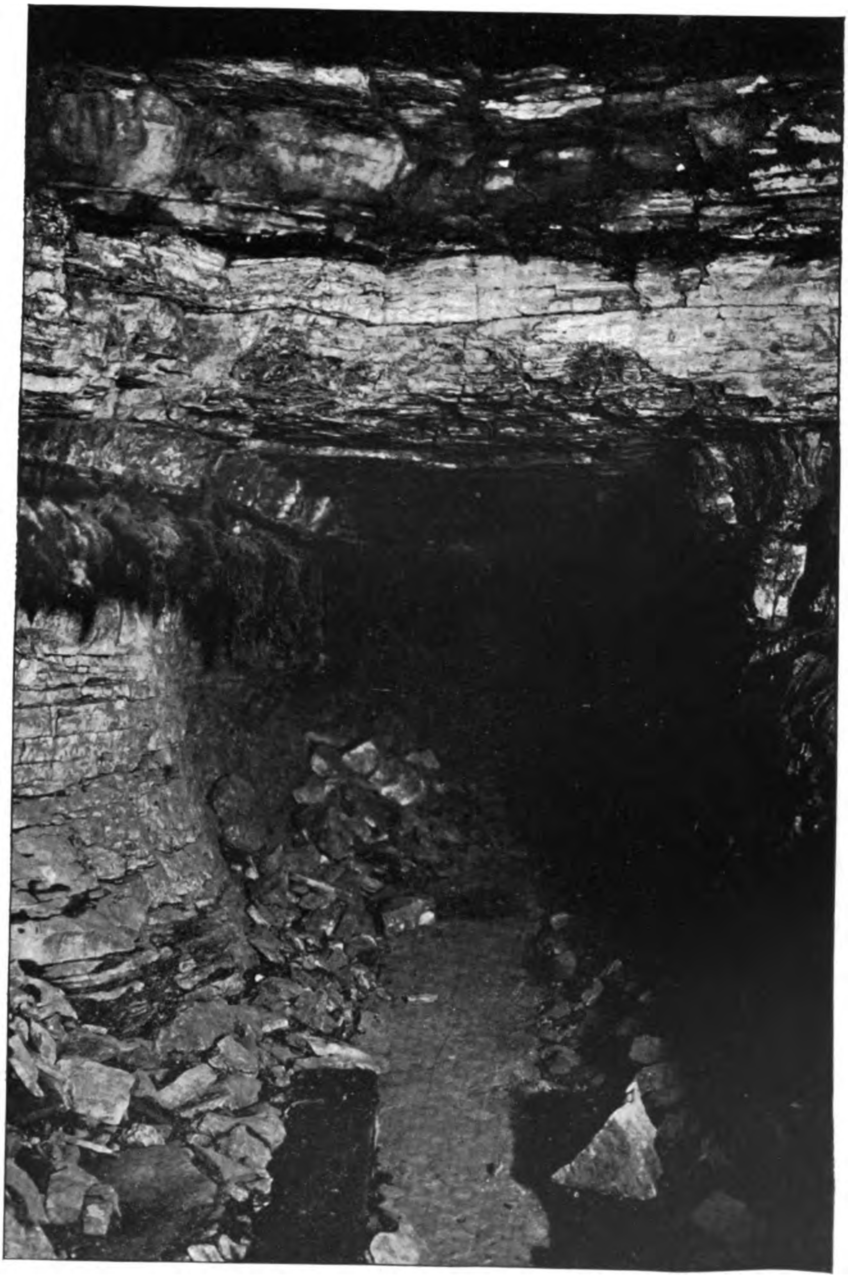
would require that the summit of the crystallines now constituting the Hudson Highlands should have been on a somewhat lower level than that of the peneplain to the north, east or west. Thus the Hudson slowly cut its gorge through the hard crystallines while at the same time the valley above was widened in the more easily eroded strata. Above the Highlands the Hudson has the habitat of a subsequent stream, but at that point it changes its entire character, becoming at once an abnormal type of stream, such as could only be produced by superposition, either on a peneplain or through the intermediation of coastal plain strata which formerly covered the crystallines. Of these two views the first appears to be the correct one.

Minor erosion features of the Schoharie region. Though the three principal streams of this region have cut their valleys without much regard to the character and position of the strata, for reasons already discussed, all the minor erosion features are fully in accord with the character of the beds from which they are carved. The prominent terraces of West hill or Terrace mountain are a striking example of the control which the strata exert, for here each hard bed has formed a prominent cliff, while the softer beds have produced slopes between the cliffs. The retreat of the cliffs is largely due to the weathering of the softer strata, through which the support for the limestones is removed, whereupon the latter break down in blocks, leaving a vertical cliff. Good examples of this retreat may be seen on the cliff of West hill, and on the road leading up Barton hill from Shutter's Corners. Among the most interesting results of rock weathering in this region is the formation of rock shelters at the base of the heavy limestone beds. These shelters are often of fair size, and will easily protect a small party during rainstorms. They are common along the contact line between the Manlius and Coeymans and between the New Scotland and Becraft, the best examples being found on Dann's hill [*see* pl. 10–12]. One of the most interesting of these shelters is behind the house of Mr Samuel Clarke on Dann's hill, and about a hundred feet above the road. It is worn along the New Scotland–Becraft contact line, the

Becraft forming a strong projection. A pillar of upper New Scotland supports the most projecting portion of the Becraft and so produces an arch 4 feet high [pl. 12].

Caves. A considerable number of limestone caverns have been found in the Schoharie region but none have reached more than local celebrity. The two best known are Ball's cave on Barton hill [map: XIIIc, 12] and Howe's cave near the station of that name on the Delaware and Hudson Railroad. Only the latter has been made accessible to the public, though in recent years it has been much neglected and is scarcely any longer visited. It is of the nature of a long narrow fissure in the Manlius limestone occasionally widening into chambers of some considerable extent, the walls and roof of which are incrusted with stalactites and the floor covered with stalagmite deposits. The entrance to the cave is at the side of the hill and continues mostly on the same level. It clearly represents an ancient underground river channel which was probably tributary to the Cobleskill, and is almost wholly dissolved out of the Manlius limestone. The entrance to this cavern is shown in plate 22. It was discovered in 1842. Ball's cave was first explored in 1831 and was at that time one of the few caverns known in this country. Originally discovered by Mr Ball, the proprietor of the land, it subsequently passed into the hands of W. H. Knoepfel, who announced his intention of opening the cavern to the public in 1854. The project however was abandoned and the condition of the cavern is today what it was 75 years ago. It is most readily approached from the road which ascends Barton hill north of the limestone outcrops. Just after crossing the Schoharie–Schenectady boundary line a private road leads southward to the house of Mr Charles H. Van Pelt. From here a wood path of about half a mile in length brings one to the cave entrance. This is merely a rather wide fissure in the Coeymans beds which everywhere in this region are strongly fissured. The main cavern is dissolved out of the Manlius strata, its greatest depth being about 60 feet. Sink holes are numerous in the region about the cave. The following description of the exploration of

Plate 22



Howes Cave entrance

this cave was published in the *American Journal of Science*, 1835, 27:368-70, by Dr Charles U. Shepard of Yale University. (Compare fig. 224 and 225.)

Notice of Ball's cave, Schoharie N. Y.

The first intimation of the existence of the cave is derived from Mr Ball upon whose land it occurs. He had observed a conical depression in the soil to the depth of 12 feet, which terminated in an irregular perpendicular fissure in the lime rock 10 feet in length and 6 in breadth. In September 1831 Mr John Gebhard, a gentleman to whom the taste for mineralogy and geology in his neighborhood appears to be principally due, in company with Mr Hubbard and Mr Branch made arrangements for ascertaining the extent of the cavern. The two latter gentlemen were lowered by ropes down a perpendicular descent to the distance of 75 feet; when the opening assumed an oblique direction to the south, although it still continued somewhat precipitous. Having disengaged themselves from the ropes, and prepared the necessary lights, they descended about 55 feet through a passage varying in width from four to 10 feet. Here the descent became perpendicular for 15 feet, after which they proceeded as before about 30 feet, when they reached the bottom. The cavern here is only about 10 feet in width, but of great hight, on one side of which is a small stream of pure and limpid water, running in a southerly direction. Passing under an arch so low as scarcely to enable them to stand upright, they followed the stream about 20 feet, when they penetrated by an opening just large enough to admit a man of ordinary size, into an apartment 20 feet in diameter, and above 100 in hight. Its sides were covered by crystalline masses of calcareous spar and the roof by stalactites, dripping with water. The effect of the torches upon this apartment is described as being very brilliant. The skeleton of a fox (as it is supposed) was subsequently found in this place; it must have fallen through the opening above and found its way here, where it probably perished from hunger. Leaving this apartment, they pursued the course of the stream for about 20 feet, through an opening from eight to 10 feet in width, when their progress was checked by a considerable body of water, into which the brook emptied. These adventurers were now compelled to return to the surface.

In October, the investigation was renewed by Mr Gebhard, Dr Foster and Mr Bonny, who had prepared a boat to navigate the water which had checked the progress of the first expedition. Fixing a light upon the prow, they commenced their voyage by

passing through an arched passage in the rock so low as not to admit of their standing erect in the boat. Having proceeded about 50 feet in a southerly direction, they altered their course to the left around an angle in the rocky passage, and found themselves in water about 30 feet in depth, and so limpid that the smallest object might be seen at the bottom. The course of the water was varied by the projections of the passage, which gradually expanded to 20 feet in width, being of a hight sometimes not discoverable, and at others only sufficient to enable them to pursue their way. They thus proceeded about 300 feet, when they arrived at a rugged shelving ascent, on the right shore of the lake, and beneath which its waters disappeared. Leaving the boat, they landed upon this sloping ascent, and advancing 20 feet they entered an aperture in the rock resembling a door, when they found themselves within an amphitheater, perfectly regular and circular in form. Its diameter is 100 feet, and its hight is supposed to be still greater. The floor descends on all sides gradually to its center, while the roof is apparently horizontal. Its walls are described as rich in stalactitic decorations. Great numbers of bats, disturbed by the intrusion of the adventurers, were seen flying about the cavern.

Subsequent visits led to the discovery of five additional apartments, communicating with the amphitheater, all of which however are small and none remarkable, excepting one in which the circulations of currents of air or of water, or probably of both, produces sounds like the Aeolian harp.

Returning to the lake, where the adventurers landed, it was noticed that upon the north side of the perpendicular entrance to the amphitheater there existed a low and narrow aperture, through which a small stream issued. The opening above the surface of the water was only 14 inches high; but its dimensions were seen to be greater within. A boat was constructed to suit this opening, through which it was pushed containing a single person in a recumbent posture. After a few feet, the passage enlarged enough to allow the navigator to assume an upright position; and he proceeded to the distance of a quarter of a mile, the width of the passage varying from 5 to 20 feet. Here the water was 30 feet in depth, and losing sight of the light he had left at the commencement of his voyage, in consequence of a turn in the passage, he advanced in a new direction for about 60 feet, when he encountered a semicircular dam of calcareous tufa, over which the water broke with a slight ripple. Drawing his boat over the obstruction he proceeded as before, when he soon met a similar barrier. In this manner he passed 14 of these dams, which varied

in hight from 2 to 12 inches above the surface of the water. The obstructions being passed, he soon reached the extremity of the water, where quitting the boat, he entered a low and narrow passage, which soon became connected with a spacious room, at least 50 feet square. The rock is represented as here passing into a kind of greywacke, in consequence of which few incrustations were visible in this apartment. The floor was covered by large masses of rocks, which had been apparently precipitated from the roof; and the sound of a distant waterfall was heard from this place.

A sectional view [fig. 224] and ground plan [fig. 225] of this cave are herewith given. They are redrawn with some omissions (of designed but never perpetrated "improvements") from old woodcuts in Knoepfel's article already referred to.

Two other small caves are found in the vicinity of Schoharie; Clark's or Gebhard's cave, on the lower slopes of Dann's hill a short distance north of the bridge across the Schoharie [map: Xg, 25] and Becker's cave under Lasell park behind the Lutheran cemetery in Schoharie. The entrance to Clark's cave is in the Rondout beds, a short distance above the Cobleskill [*see* section, fig. 199]. A stream issues from it, falling over the Cobleskill and following a ravine of some depth. Becker's cave is in the thin bedded Manlius and opens directly in the face of the cliff [*see* pl. 23]. Stalagmitic deposits of considerable size and some beauty have been taken from this cave.

Glacial phenomena. The last of the many pronounced changes which the Schoharie region has suffered was due to the invasion of the ice of the glacial period. Great erosive power is often ascribed to the ice, and it has even been suggested that the Schoharie and Cobleskill valleys were the result of glacial erosion. We have seen however that the normal processes of stream erosion are fully capable of accomplishing such results, and there is practically no evidence that ice was the agent which cut these valleys. Some erosion was done by the ice, as is seen by the smooth and striated surfaces of the harder rocks wherever exposed. But this erosion was more of the nature of a sandpapering off after the main work of cutting the valley was

accomplished by the streams. The deposits of till or ground moraine which were left in portions of the valley bottoms and which now serve as sites for cemeteries, constitute the chief topographic features due to the ice. On the upland this deposit of ground moraine is very characteristic and in the region between Central Bridge and Cobleskill it mantles most of the outcrops. The surface of the country has here the peculiar rolling topography due to morainal deposits. Deposits of stratified sands appear to be very rare in the Schoharie region, but they are of marked character farther north in the Mohawk valley.[1] The direction of the glacial striae and furrows on East hill were found to be n.50°e., and on Vroman's Nose n.80°e. [Prosser].

[1] For an account of the topography and glacial deposits of the Mohawk valley *see* A. P. Brigham, Geol. Soc. Am. Bul. 9:183–210.

Plate 23

Entrance to Becker's cave, below Lasell park

Chapter 9

THE SCHOHARIE REGION IN ITS RELATION TO MAN

Economic geology

The industrial development of the inhabitants of any given region is in a very large degree influenced by the geologic conditions of that region. This is particularly true of rural communities, and is well expressed in the history of the settlement of the Schoharie region. The flat valley bottom, rich in agricultural possibilities, afforded a haven of refuge for the persecuted Palatines who settled in the Schoharie valley in 1713. They built seven villages or Dörfer, which extended from the mouth of the Cobleskill to the mouth of the Little Schoharie near the present village of Middleburg. The springs of pure water, so abundant along all the contacts of impervious and pervious strata, the easy mode of communication both by land and by the stream, and the waterpower of the hill streams might well have been additional sources of attraction to the early settlers, specially as the Indians were ready to live on friendly terms with them.[1]

As in all isolated communities, agriculture was almost the only pursuit of the early inhabitants, and it has remained so to a large extent down to the present time, though manufacturing is engaged in in all the larger towns along the railroads.

The economic geologic deposits of the Schoharie region are almost wholly confined to the Paleozoic rocks. The various limestones are among the most important economic products of the region, and they have been exploited to a considerable degree though by no means to the extent we may look for in the future. The lowest of these, the Cobleskill, has been quarried on a small scale, for building purposes, a small church in the northeastern portion of the town being built from stone quarried in place. Brown's quarry, about a fourth of a mile east of Schoharie post-

[1] For a concise account of the early history of this region *see* Prof. Solomon Sias's admirable "Summary of Schoharie county."

office is the only one in which this rock has been quarried to any extent. Being of a rather coarse grain, it serves well for foundations and will dress readily. Some of the beds are of sufficient thickness to form good blocks. The strata immediately above this bed are quarried a short distance south by Mr Vroman, the rock having been used for foundation in the new Schoharie schoolhouse. Somewhat higher up in the field the higher Rondout beds are taken out. The only locality where the Rondout waterlime is extensively quarried in this region is at Howes Cave, where the Helderberg Cement Company uses this rock for the manufacture of natural or Rosendale cement. The stratum used lies just above the Cobleskill and is six feet thick. An analysis of this limestone gave:[1]

Lime carbonate	55.17
Magnesium carbonate	19.71
Silica	12.89
Ferric oxid and alumina	11.15
Water	.66
Loss	.42
Total	100.

At this locality the beds immediately succeeding the cement bed and for nearly 50 feet above it are not utilized. Above this about 36 feet of Manlius and about 30 feet of Coeymans occur. These are quarried together and manufactured into Portland cement. While the natural cement rock has been used for a long period of time for the manufacture of natural cement, the Portland cement industry only began here in 1898. It was commenced on a small scale, but rapidly grew as the demand for Portland cement increased. In 1900 a new plant with a nominal capacity of 1500 barrels a day was erected. The process of manufacturing the cement is as follows:

The limestone is crushed and mixed with the proper amount of clay in the presence of water by what is known as the "wet process". This is done in cylindric tanks in the center of each

[1] Ries. N. Y. State Mus. Bul. 44, p. 817.

of which is a revolving shaft carrying a wooden frame with scrapers. This frame makes about 20 revolutions a minute and stirs and thoroughly mixes the ground limestone and clay. The thoroughly mixed material is then transferred to a large revolving iron cylinder whose axis of revolution is slightly inclined from the horizontal. The mixture after having been dried "is charged at the upper end of the cylinder and oil or gas fuel blown in at the lower, the gases of combustion passing through the chamber and out at the upper end, while the cement mixture slowly passes down through it, the burned clinker being discharged at the lower end."[1] It is very essential that the temperature should be regulated, so that the burning may not be overdone, in which case the cement will not "set" properly. The changes produced in burning are, 1) driving off of the mechanically combined water, 2) driving off the CO_2, and 3) fusing together the silica, alumina, lime and iron, all of which except the lime are chiefly obtained from the clay which has been added. The clinker is finally subjected to repeated grindings till it is of the proper degree of fineness, when it is packed in bags or barrels and marketed as "Helderberg" brand of Portland cement.

Analyses of the limestones used gave the following results.[2]

	SiO_2	$CaCO_3$
Manlius	1.48	95.75
Coeymans	4.12	93.68

The clay used in the process was formerly obtained from Howes cave. The accumulation on the floor of the cave represents the impurities left behind during the solution of the limestone in the process of formation of the cave. At present the glacial clay from the Cobleskill valley near Howes Cave is used.

In the Schoharie valley the Manlius and Coeymans limestones have been quarried for lime, for crushed stone and for building purposes. The Manlius was formerly burned in the quarries below Lasell park, but at present no lime is manufactured in this region. Extensive quarrying operations are however carried on by Messrs Mix & O'Reilly in the northeastern part of the village. Here the Rondout and Manlius are taken out and crushed for road metal. The Coeymans limestone has been quarried for the

[1] Ries. *Loc. cit.*, p. 711.
[2] Eckel, Edwin C. N. Y. State Mus. Bul. 44. apx. p.869.

same purpose in the cliff southeast of the Lutheran cemetery in Schoharie. Near Barnerville the Coeymans is extensively quarried for building purposes. Rocks for foundations have also been obtained from the heavy bedded Manlius in the various quarries behind Schoharie, but all such work is carried on at present only on a small scale. The Becraft limestone, the purest and best of the region has scarcely been utilized.

A quarry has been opened in the Becraft by Mix & O'Reilly, on the slope of East hill above Schoharie, and another, now abandoned, is found where this rock has reached the lowland level near Frisby's Mills. No analysis of the rock has been obtained, but judging from its similarity to that of Becraft mountain and other localities in the Helderbergs, it would appear that it is admirably fitted for use in chemical works, or for the manufacture of Portland cement.

The Oriskany rock has been used for stone fences and locally to a slight extent for foundations, but it is not well adapted to building purposes on account of the readiness with which it disintegrates. The Esopus has been used locally for road mending but with little success. It disintegrates however into good soil and has yielded a local covering of soil for the Oriskany quartzite. The Onondaga, though outcropping on all the hillsides above Middleburg and Cobleskill, has not been exploited to the extent one would expect. At the town last mentioned are extensive quarries of the rock though mostly abandoned. Some quarrying operations in this rock have also been carried on along the banks of the small stream which joins the Schoharie kill at Davis crossing.

The Hamilton sandstones are locally used for foundations, but on the whole not much material of value is obtained from this formation in the Schoharie region. In Albany county however several extensive flagstone or bluestone quarries have been opened in the upper beds of this formation. The nearest are in the vicinity of Reidsville, South Berne and Rensselaerville.

The Sherburne, Ithaca, Oneonta and Catskill formations have also yielded flagstones, or sandstones for building purposes but

all the quarries in these rocks are too far removed from the Schoharie region to be here considered.

Economic deposits other than limestones or sandstones are not found in the Schoharie region in paying quantities, though unsuccessful exploitation of various mineral deposits has been carried on. The most prominent of these are the strontium deposits in the Rondout beds, the iron pyrites in the Brayman shales and the bituminous shale or "coal" of the Marcellus.

Strontium. The strontium deposits at one time bade fair to become of considerable importance. In 1829[1] John Gebhard jr, discovered a locality of acicular strontianite in the waterlime strata not far above the Cobleskill limestone, in the cliff east of Schoharie village, near where Mix & O'Reilly have opened up their lower quarry. At first he regarded the mineral as calcareous spar, but the discovery of another locality behind the courthouse, where massive strontianite and heavy spar occurred, led to the recognition of the acicular crystals as strontianite. Further exploration was carried on by tracing the waterlime bed, which carried the strontianite along the hillsides, and several localities along both sides of Fox kill were discovered. A locality on the northeastern face of West hill, discovered some 15 years before, and known as the "Marble quarry" was reexamined by Mr Gebhard and others, and the rock found to be the same as that carrying the strontianite on East hill. This led to the recognition of the white massive mineral in these ledges as strontianite, which identification was confirmed by analysis. This is the only locality which has been worked for the strontium minerals, mining operations having been carried on formerly, on the steep hillside at the base of the cliff, and the product lowered by buckets along a wire cable. The locality is familiarly known as the "Strontium mine." It may be approached by a steep zigzag path which ascends the talus slope from a point about opposite where the Schoharie makes a right-angled bend just before it is joined by the Fox kill. A stream descends the hill here, but its bed is hidden

[1]Gebhard, John. Am. Jour. Sci. 1835. 28:175.

in the dense brushwood. When dry, as it is during the summer season, the stream bed may be recognized where it leaves the wood and enters the flats, by the presence of much calcareous tufa. The mine may also be approached by a steep path from above. This begins as a wood road on the terrace about 100 feet below the red barn of Mr George Acker on West hill. The path descends over the cliffs about two thirds of a mile beyond Mr Acker's place. The mine is in the form of a fissurelike tunnel [*see* pl. 24] and the mineral may be seen in the beds on both sides of the tunnel in large geodic masses of a milk white color. Some of these have the aspect of having replaced heads of Stromatopora or other fossils. This mineral was formerly known as "marble," which it resembles. Calcite, often in the form of nailhead spar, is found in some of the geodes.

The discovery of the strontianite was announced by Prof. Ebenezer Emmons in 1835.[1] It was at that time the only known deposit of this mineral in the United States.

The following description of the varieties is by Dr C. U. Shepard of Yale University.[2]

The most obvious variety is that in acicular crystals, and massive in long, straight, divergent individuals. It occurs, occupying irregular cavities, from half an inch to several inches across; the crystals and fibrous masses being implanted upon a dark blue calcareous spar which is granular in large individuals, or crystallized in obscure scattered dodecahedra, whose apexes are replaced by three, six, nine or 12 faces. The envelope of calcareous spar is sometimes of considerable thickness, and is itself often included within the layer of heavy spar, massive in large lamellar individuals, some of which penetrate the calcareous spar. But the strontianite constantly reposes upon the latter mineral. The crystals are often 3/4 of an inch in length, and from the diameter of a pin to that of a hair. The aggregated, columnar individuals frequently exhibit at the extremity where they diverge most, crystalline faces. Some of these fibrous aggregations are two inches in length, and bear a striking resemblance to certain varieties of aragonite. Minute crystals of iron pyrites, crystallized in the form of pentagonal dodecahedrons, are scattered here and there

[1] Am. Jour. Sci. 1835. 27:182.
[2] Am. Jour. Sci. 1835. 27:364–67.

Plate 24

The Strontium mine. A fissure in the Rondout and Manlius on Terrace mountain

through the calcareous spar. The color of the strontianite is white, or slightly tinged with grey or blue; and it is semitransparent or translucent.

A second variety quite different in general appearance from the first . . . . is massive, indistinctly lamellar, and approaching to impalpable. Color, milk white, rarely with a delicate and almost imperceptible shade of green. This variety occurs in veins, from a quarter of an inch, to two inches wide, and is embraced directly by clayey limestone. Rarely, it is traversed by large lamellae of heavy spar, which are easily distinguishable by their crystalline texture. Very small quantities of calcareous spar attend this variety occasionally, but it is not of a blue color. The circumstances of its deposition appear to have been different from those of the first variety. . . . . .

A third and more interesting variety . . . . . . appears to form a vein of considerable size, the mass of which resembles the last variety in structure and color, as well as being traversed occasionally by lamellae of heavy spar. But upon one side of the masses, tabular crystals of strontianite single and compound, an inch in length, and one third of an inch wide, are thickly implanted on a surface of transparent crystals of calcareous spar. The calcareous spar is in large crystals of the form of the *metatastique*. The strontianite is partially coated by a white powder, as if it were suffering decomposition,[1] and the crystals of calcareous spar are covered completely by little fissures and cavities, where the strontianite once penetrated them. It is observable however, that the large crystals of strontianite still remaining are connected among themselves, as also to the mass of massive strontianite below. Small transparent crystals of quartz are also disseminated through the calcareous spar, but no iron pyrites is present. . .

Still another variety of strontianite comes, apparently from the same place. It occurs in cavities or geodes, surrounded by bluish calcareous spar, but without the heavy spar; and offers the largest and the best pronounced crystals. . . They are an inch in length, and nearly half an inch in thickness; color, bluish or reddish grey; translucent.

The most singular crystallization, and one most likely to be overlooked from the smallness of the crystals, and their want of luster, is that in octahedra with rectangular bases, the longer edges of the base being to the shorter as five to one. The smaller

[1] The only suggestion that offers itself to my mind in explanation of this incipient decomposition is, that sulfuric acid may have been produced from the oxidation of the sulfur in the iron pyrites, and have formed a slight coating of sulfate of strontia upon the crystals of the strontianite. [C. U. S.]

pyramidal faces, I take to be the lateral planes of the primary form, and the broader ones to be the secondary faces, arising from the truncation of the oblique angles of the primary crystal. These crystals vary in length from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch, are dull, grayish white, and with rough faces, often covered by crystals of iron pyrites. They are so thickly disseminated through the clayey limerock as to form two thirds of its mass, and render it very difficult of fracture. The form of its crystal can scarcely be detected, except at the surface of those masses which have been weathered, when their rough and dull faces appear. . .

The last and the most interesting variety, if we consider the ambiguity its determination presents, and the immense quantity in which it exists, is the milk white, massive variety. . . And I confess I should have been slow to pronounce it strontianite, except that the cleavage indications of heavy spar and of celestine were both wanting, and that it closely resembled a massive variety, accompanying the compound crystals above described. It somewhat resembles the purest white variety of petalite, although the particles of composition are occasionally arranged in a manner to give a broad reflection, and its luster is more resinous than vitreous. Specific gravity = 3.5.

I could not detect with the microscope the smallest particle of calcareous spar, or heavy spar, or indeed any other substance, intermingled with the mass. But to make sure of the absence of the latter mineral, a small fragment was pulverized and introduced into a glass flask, upon which dilute muriatic acid was affused. It was immediately dissolved with effervescence, without leaving the slightest residue.

"A fibrous heavy spar in delicate parallel fibres about half or three quarters of an inch long" has been found in the southeast corner of the town of Carlisle, seven miles northwest of Schoharie Court House. The exact locality has not been recorded, but is near the hamlet of Grovenor Corners. It is said to occur in "a blue gray slate beneath the limestone". This may be the Brayman shale, but it is more likely that the mineral occurs in the shaly Rondout beds. Associated with this is a fibrous aragonite, in which the fibres are of the same diameter, but of double the length.

A deposit of blue gray celestite in tabular crystals has been obtained in considerable abundance from the waterlime in the cliff east of Schoharie. Loose specimens are found in the stone

fences and may be recognized by their color, crystal form and great weight. The mineral was examined chemically by Dr V. J. Chambers of Columbia University, who found it to be strontium sulfate, with some barium sulfate admixed. From this analysis it appears that the mineral is in reality barytocelestite. The occurrence of this mineral on the north end of East hill was noted by John Gebhard esq.,[1] who speaks of it as a variety of the strontianite. He describes the mass as "chiefly an aggregation of crystals, and so slightly cohering as with difficulty to be removed from its bed".[2]

Other minerals found in the waterlimes are fluorite, aragonite, satin spar and calcite in various crystal forms.

Iron pyrites is an abundant mineral in the Schoharie region, occurring everywhere in the Brayman shales. Crystals of the pyritohedron or pentagonal dodecahedron are common but the usual occurrence of the mineral is in globular masses made up of small crystals, and in size varying up to that of a man's fist. The mineral has been exploited to some extent for iron and sulfur, and the exposure on the river bank above the Gebhard residence is often referred to as the old iron mine. In the upper beds of the Brayman shale at this place arsenical pyrites has been found.

Coal. By far the most hopeless of all the search after valuable mineral deposits in this region has been that for coal, despite the fact that ever since the geologic structure of the State has been understood, it has become a common dictum that search for coal in New York State was fruitless. Disregarding the frequent warnings of the geologists, expensive excavations for coal have been repeatedly made. Mr Gebhard records the fact that a hole was drilled early in the last century near the pyrite mine in the vain search for coal in the Lower Siluric shales. Within the last few years an opening has been made and a drill hole put down, on the slope of South hill, less than a mile

[1] On the Geology and Mineralogy of Schoharie, N. Y., by John Gebhard. esq. Am. Jour. Sci. 1835. 28:172.

[2] *Loc. cit.* p.173.

northeast of Middleburg. The opening was made in the upper Marcellus black shale, just below a covering of coarse Hamilton sandstone. The bed supposed to be coal is four feet thick. It is a strongly carbonaceous shale much slickensided or broken by the pressure of the overlying rock mass, which has caused a certain amount of shearing movement within the mass. The resultant product might be mistaken for coal by one who had no knowledge of the mineral character of anthracite or bituminous coals, but could hardly deceive the experienced. Other excavations for coal have been made in this formation at Cobleskill, Punch brook and near Middleburg.[1]

While thus the economic heritage of the Schoharie region is chiefly derived from the Paleozoic age, the other ages of the earth's history have also left their stamp on this district, and the results of the dynamic activities during these later ages have become potent factors in its industrial development. It was during the Secondary or Mesozoic era of the earth's history that the extensive denudation occurred which reduced this region to the condition of a peneplain. Since this peneplain bevels the strata, the lower beds, formerly buried under thousands of feet of upper Devonic sandstones, became exposed and thus accessible. The Tertiary or Cenozoic era witnessed the cutting of the valley system which now dissects this ancient peneplain, uplifted into a plateau, and which is the primary element in the diversified topography of this district. Last of all the Quaternary or Psychozoic era brought the ice invasion thus covering the hillsides and uplands with the glacial drift, which constitutes the soil of otherwise barren districts and which also is the source of all the gravel sand and clay deposits of the region. This same era, finally, has witnessed the advent of man, and the wonderful changes due to him, at once one of the weakest, and also one of the most powerful factors which influence the development of the surface of the earth.

[1] Mather. Geol. 1st Dist. p.323.

GLOSSARY OF TECHNICAL TERMS

acicular—needlelike
aggrade—to build up to the condition of grade, as in a river
annulated—ringed, generally encircled by raised rings
annulations—raised rings
anterior—front
aragonite—orthorhombic calcium carbonate, a common mineral
arcuate—arched
arenaceous—of the texture of sand i. e. composed of visible sand grains irrespective of chemical composition
argillaceous—composed of or containing clay or hydrous silicate of aluminium
arsenicopyrites or arsenopyrite—a mineral of a pale brass or almost silvery color and in composition sulfid and arsenid of iron

barytocelestite—the compound sulfate of barium and strontium, a combination of the minerals barium and strontium
beak—in pelecypod or brachiopod shells, the point of beginning of growth of the valves
bifurcating—dividing in two; forking
bivalve—possessing two valves, as a pelecypod, a brachiopod or an ostracod crustacean
brachial valve—in the brachiopods, the valve which supports the brachidia or arms; it is generally the smaller of the two
brachiopods—a class of marine invertebrates, with bivalve shells, the valves symmetric about a median line drawn from beak to base of each. A brachial and a pedicle valve are distinguishable
breviconic—forming a short stout cone as in Gomphoceras
bryozoan—a class of invertebrates building compound coral-like structures either cylindric, with the cells radiating from a median axis, or leaf or fernlike with cell openings, generally on one side only. The spreading types often incrust seaweeds, shells or other objects

calyx—the cup or living cavity in corals; the "head" of crinoids
camerae—the air chambers in the cephalopod shell
cancellated—marked by two sets of intersecting ridges or grooves
carbonaceous—carbon or coal-bearing
cardinal—appertaining to the region of the hinge in bivalve shells
cardioconchs—pelecypods of the type of structure of the cockle shell (Cardium)
carina or carination—an elevated ridge
celestine—*see* celestite
celestite—the mineral form of sulfate of strontium
cephalon—head of Crustacea (trilobites)
cephalopods—a class of marine mollusks typically with a shell straight, curved or coiled, divided into chambers or camerae by partitions or septa, which latter are pierced by holes drawn out into more or less perfect tubes—the siphuncle
cyrtoceracone—a cephalopod shell curved without coiling as in Cyrtoceras

checking—breaking up into small checkerlike square fragments characteristic of some mudrocks

chert—the amorphous or irregular form of silica occurring in limestones (flint)

clastic rocks—rocks composed of fragments of older rocks—e. g. sandstones, conglomerates etc.

cleavage—(mineral) the property of splitting along certain planes determined by the crystalline structure

(rock) splitting into parallel sheets as in the case of roofing slates

coastal plain—the level plain composed of horizontal or gently sloping strata of clastic material fronting the coast and generally representing a strip of recently emerged sea bottom

col—the low saddle connecting two hills or peaks

conchoidal—with a curved surface marked by lines resembling the lines on a clam shell; the type of fracture found in glassy rocks or shown in thick glass

concretion—a rock mass of varying form resulting from the segregation of mineral matter from all portions of the parent rock in favorable spots within this parent rock. The form, composition and mode of formation varies greatly

conformation—having a parallel position with reference to each other, as two strata or beds

conglomerate—a clastic rock composed of waterworn pebbles embedded in a matrix of varying composition

consequent stream—the type of stream resulting from the flow of water down a constructional slope or land surface

coralline limestone—limestone composed of or containing many corals or coral-like remains, specifically the Cobleskill limestone

corallite—one of the members or tubes of a compound head of coral, as in Favosites

correlation—determination of the equivalency or relative age of geologic formations in separated localities

costae—ribs on the surface of shells or other organisms

coquina—a rock composed entirely of shells, generally but little broken

crenulations—fine ridges or toothlike markings

crinoids—a class of marine invertebrates of the division Echinodermata, consisting typically of a body or calyx composed of more or less regular series of plates, set generally on a jointed stalk or stem, and bearing arms. A "sea lily"

cross-bedding—the variable angle of the layers or beds within a stratum of rock produced by strong currents, specially in rivers

cuesta—a topographic form resulting from the normal erosion of coastal plain strata of varying hardness, and comprising a steep escarpment or inface facing the old land and separated from it by a parallel valley and a gently sloping upper surface formed by a resistant stratum. *See* illustration in body of text, figure 210

cycle of erosion—the interval during which a land surface newly uplifted either as plain or mountain is worn down to the level of the sea (base level)

cystoid—a class of organisms related to the crinoids, but with the calyx composed of irregular plates

degrade—to wear down to the condition of grade—as in a river
dental plates—plates or brackets supporting the hinge teeth in the brachiopod shell
dichotomous—branching in a bifurcating or forking manner
dip—the relation which an inclined stratum bears to a horizontal plain
discoidal—disklike
disintegrate—break up by the combined action of chemical and mechanical forces
dissepiment—small discontinuous connecting plates between the septa of corals
dodecahedron—the crystal form in which 12 equal diamond-shaped faces occur—example, garnet
dodecahedron—pentagonal—the crystal form (hemi-tetrahexahedron) in which 12 equal faces, each of the form of a regular pentagon occur. Characteristic of pyrite.
dorsal—pertaining to the back or dorsum
dynamic—pertaining to or involving forces

ear—the anterior division of the hinge of pelecypods
elevation, median—*see* fold
emargination—marginal notch
estuarine—appertaining to an estuary or the mouth of a river
exogastric—in coiled cephalopod shells with the ventral sinus on the arched external side

fault—displacement of strata with reference to each other on opposite sides of a fracture line
fauna—the sum total of animal life of a given region, a given formation or a given time
ferruginous—iron-bearing
fissile—splitting into thin, more or less papery sheets
fluorite—the mineral form of calcium fluorid
fold—a bend in the strata
fossils—remains of animals and plants or direct evidence of their presence preserved in the rocks of the earth
fragmental rocks—same as clastic rocks
furrows, glabellar—the transverse depressions on the central portion or glabella of the trilobite head
furrows, lateral—side depressions bounding the glabella of the trilobite head
furrows, occipital—basal depression separating glabella from last ring of head of trilobite (occipital ring)

gastropods—a class of invertebrate mollusks, typically with a coiled shell as in the snails
genal angles—the angles of the cheeks or lateral angles of the head of trilobites
genal spines—the lateral or cheek spines of the trilobite head
geodes—hollow concretions lined with crystals or massive mineral matter
gibbous—thick, bulging
glabella—the central portion of the head of trilobites

goniatites—a group of cephalopod mollusks with a coiled shell in which the margins of the septa or sutures are complicated by simple lobes and saddles. It is not a natural group
greywacke—an old name for gray arenaceous and argillaceous rocks—not much used
grit—a silicious sandrock with coarse grains—something between a sandstone and a conglomerate. It is often loosely used for either
gyroceracone—a conic shell (cephalopod) coiled in a loose spiral in a single plain, as a watch spring

hiatus—an unrepresented interval
hinge area—the flattened area margining the hinge of brachiopod or pelecypod shells
horizon—position in the geologic time scale
hydrocorallines—a group of marine organisms building coral-like structures, but lacking some of the essential structural characters of corals
hyponomic sinus—the marginal sinus or depression in the rim of the living chamber of cephalopod shells corresponding to the position of the swimming organ or hyponome
hypostoma—the lip or movable plate of varying form attached to the under rim of the trilobite head, and behind which is situated the mouth

impervious—impenetrable to water
incise—cut down into, as a river cuts into a plateau
index fossil—fossils which mark a special horizon irrespective of the nature of the sediment
inface—the cliff portion of a cuesta i. e. the part facing the old land
inner lowland—the belt of lowland or valley country lying between the inface or front of the cuesta and the old land
insequent stream—streams beginning as runs over the edges of a cliff, where they cut a gully which gradually becomes elongated
intercalation—insertion between
interseptal—occurring between the septa
interspaces—spaces between
iron pyrites—*see* pyrite

joints—natural planes along which rock masses separate into more or less regular blocks

keeled—bearing a keel
kill—Dutch for creek

lamellar—in the form of plates
lamellibranchs—a class of mollusks with a bivalve shell, the valves being right and left and each unsymmetric in itself—pelecypods, ex. clam. mussel
lamellose—platelike
lateral—pertaining to the side
lime mudrock—a rock composed of impalpable lime mud (example, lithographic limestone) ; also called calcilutyte

lime rubblerock—a rock composed of broken or worn fragments or pebbles of limestone or organic fragments (shells, corals etc.); also called calcirudyte
lime sandrock—a rock made up of lime sand; also called calcarenyte
lines of growth—the lines on the shell marking the progressive increase in size
lithic—pertaining to the nature of rock
living chamber—the last and largest chamber of the cephalopod shell, in which the animal lives
lutaceous—of an impalpable or mudlike grain invisible to the eye
lobe—the backward projecting portion of the suture line in the Goniatites and Ammonites
lobes, of glabella—the parts of the glabella of the trilobite isolated by the various depressions or furrows. They comprise anterior, lateral and posterior

marginal **rim**—in trilobites the rim surrounding the front of the head shield
master stream—the principal stream of the region
metamorphic—altered; there are three types of metamorphism: static, or by a process of aging; dynamic, or by disturbing forces as mountain folding, etc.; thermic, or by contact with heated bodies as dikes, flows or sills
monadnock—an erosion remnant projecting above the level of a peneplain
moniliform—beadlike
moraine, ground—the material carried along frozen into the bottom of a glacier and deposited on the melting of the ice
mould, external—the impression made by a shell or other body in the sand or mud in which it is buried—impression of exterior
mould, internal—the impression received by the sand or mud filling a shell or other hollow—impression of interior
mucronate—having slender projecting ends
mudcracks—the cracks formed by the drying up of beds of mud. They commonly surround polygonal plates
mural pores—the pores in the walls of the corallites of Favosites and related forms
muscular impressions, muscular scar—scars on interior of shells, etc. made by attachment of the opening and closing muscles

nasute—noselike
nautilicone—coiled shell with whorls impressing each other as in Nautilus
nautiloid—resembling or related to Nautilus
noded—bearing knobs or nodes
noncoiling—not possessing, or losing the power to coil
nonmarine—not formed by deposition in the sea—continental
nonumbilical—not having a hollow or depression at the base of the axis of coiling (umbilicus)

obsequent stream—streams flowing down the inface of the cuesta in the direction opposite to that of the consequent streams
occipital spine—spine on the basal or occipital ring of the head of trilobites

octahedron—crystal form with eight equal faces, each an equilateral triangle
old land—that portion of land behind the coastal plain which supplied the material of which the strata of the coastal plains were formed
orthid—resembling or related to the brachiopod Orthis
orthoceracone—a straight conelike shell like that of Orthoceras
orthoceratites—belonging or related to the genus Orthoceras
outcrop—intersection of rock mass with the surface
outlier—erosion remnant left in a valley at a distance from the plateau or upland with which it was previously continuous
ostracods—a group of marine crustacea generally minute, inclosed in a bivalve shell which does not show concentric lines of growth
overlap—extending beyond an underlying stratum

pedicle valve—that valve, generally the larger, of the brachiopod shell which gives emission to the pedicle or supporting organ. This valve also contains the teeth by which the hinging of the valves is accomplished
pelecypods—the class of bivalve mollusk or lamellibranchs to which the clam belongs
peneplain—the nearly level surface, almost a plain, resulting from the erosion of an uplifted region by subaerial agents, to a condition approaching sea level
pentameroid—related to the genus Pentamerus among the brachiopods
periphery—the margin of the circumference
pervious—penetrable by water
petalite—a complex silicate of aluminum with sodium, potassium or lithium
plications—folds or flutings
posterior—pertaining to the hinder end
prenuncial—announcing beforehand, heralding the coming of
protuberant—projecting outwards
pteropods—a class of marine mollusks floating on the surface of the water and having delicate generally transparent shells, needlelike in the commonest forms
punctate—marked by spots or shallow pits
pustules—small elevations or tubercles
pustulose—covered with pustules
pygidium—the posterior portion of the body of the trilobite, erroneously called tail
pyrite—the mineral form of bisulfid of iron F_e S_2
pyritiferous—containing or bearing pyrite
pyritohedron—the pentagonal dodecahedron (which see) a form commonly assumed by pyrite crystals

quartz—the mineral form of oxid of silicon (SiO_2)
quartzite—a rock resulting through the metamorphic change of a quartz sandstone, the quartz grains become closely united by a paste or matrix of quartz

radii—radiating lines, such as are found on the surfaces of many shells
revived stream—streams resuming activity owing to elevation or other causes

rhynchonelloid—related to or resembling the brachiopod genus Rhynchonella
ripple marks—wavelike elevations formed in sand or mud in shallow water or by wind on drifting sand
rostral cavity—cavity under the beak of bivalve mollusks or brachiopods
rubble—coarse broken rock material
rudaceous—consisting of coarse fragments; rubbly
rugose—rough surfaced

saddle—in ammonites the forward bending portion of the suture line i. e. bending towards the aperture
scutella—a shield; flattened shieldlike remains of crinoids
septa—the radiating plates in the cup of a coral
septum—a supporting bracket in brachiopod shells; one of the septa of a coral
shearing—cutting and displacement along the cut plain by violent means
silicious—composed of or containing silica
sinistral—left-handed
sinus—a median depression on the brachiopod shell, generally the pedicle valve
siphonal lobe—the lobe in the suture of the goniatite or ammonite shell which passes over the siphuncle
siphuncle—the tube passing through all the septa of the shells of cephalopods
slickensides—a smooth striated surface—commonly coated with mineral matter, resulting from the friction produced by two rock masses sliding past each other
spar—a general term applied to minerals cleaving with smooth surfaces
spar, heavy—barite
spar, nail head—the flat form of calcite crystals
spar, satin—fibrous gypsum
stalactite—pendant structures of calcium carbonate or other minerals deposited on the roofs of caves, etc.
stalagmite—the structure on the floor of the cave corresponding to and growing up to meet the stalactite
stratigraphic—pertaining to the strata or the science of the strata (stratigraphy)
stratum—the bed of rock composed throughout of the same material or texture
striae—fine lines or markings such as occur on the surfaces of shells, etc.
strontianite—the mineral form of carbonate of strontium
strontium—one of the earth-alkaline elements
strophomenoid—resembling or related to the brachiopod genus Strophomena
subcylindric—approaching to, but not attaining, the cylindric form
suborbicular—approaching a spheric form
subpentagonal—approaching a pentagonal or five-sided form
subquadrangular—approaching a four-sided or quadrangular form
subrectangular—approaching a right angle
subsequent stream—the stream which cuts out the inner lowland between the cuesta front and the old land

suture—the line made by the junction of the septum with the shell in the Cephalopoda. Visible when the cavities of the shell are filled with rock matter and the shell removed, the common condition seen in fossils. Also the line of junction between the coils or whorls of a gastropod shell.

talus—the accumulation of rock debris at the foot of a cliff
telson—the spine at the end of the tail of crustaceans
tenuous—drawn out finely
terebratuloid—related to or resembling the brachiopod genus Terebratula
texture—the grain of rocks
till—the unassorted material left by the melting ice sheet of the glacial period. It is generally full of boulders and contains much clay and rock flour
torticone—a twisted cone as in snail shells (gastropods) or certain cephalopods (Trochoceras)
transgression—encroachment on, as the sea advancing over the land which it submerges
trilobate—three lobed
trilobite—a class of Crustacea, longitudinally divisible into three parts or lobes and having a head or cephalon with a central glabella, compound eyes and lateral or free cheeks separated from the rest of the head by the facial sutures; a body or thorax divided into a number of rings and a pygidium or abdomen consisting of a single grooved piece. The class is confined to the Paleozoic rocks
tufa, calcareous—a deposit of porous lime carbonate formed by certain springs or streams
tumid—swollen

umbilicus—the basal cavity in the axis of circling of gastropod and cephalopod shells
umbonal—pertaining to the beak or umbo of bivalve shells
unconformity—discordant relation of strata
unconformity, stratigraphic—an unconformity marked by absence of certain intermediate formations without discordance of strata (disconformity)
unconformity, structural—a true unconformity with discordance of strata The first series is folded and eroded before the second is deposited [*see* text]

venter—underside of the body. In coiled cephalopod shells it is mostly the outside of the coil
ventral—pertaining to the underside of the body
ventricose—bulging
vermes—the class of worms
vitreous luster—the luster of glass

waterlime—limestone which on burning will form natural cement
whorls—the coils of a gastropod or coiled cephalopod shell
wing—in certain pelecypods the posterior or larger portion of the hinge region; the anterior or smaller portion is the ear

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